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Water Resource Data and Preliminary Trend Analysis for the Blue Creek Watershed Project Pike County, Illinois - Phase II

Illinois State Environmental Protection Agency
Springfield

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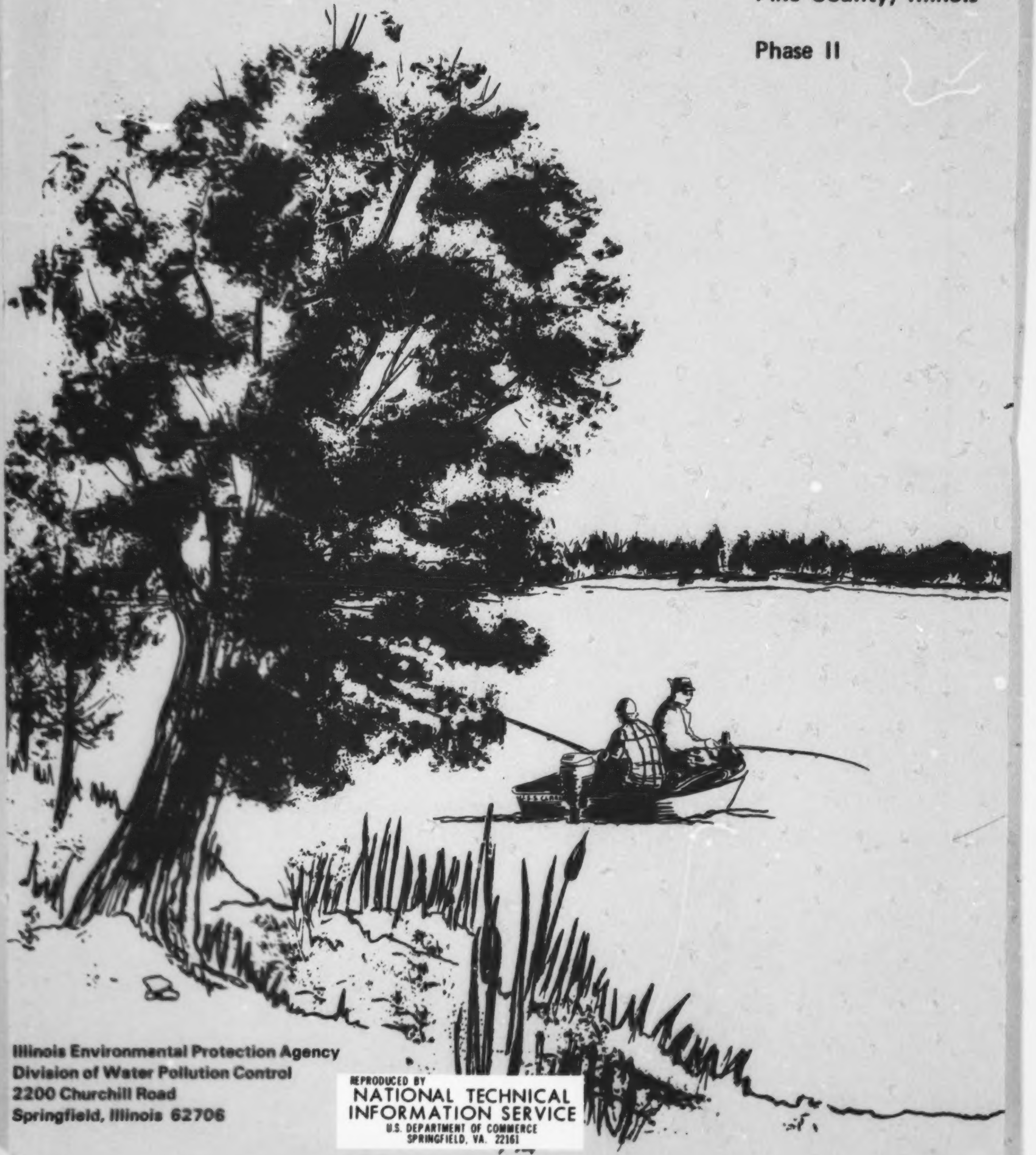
Pike County, Illinois

Phase II



Illinois Environmental Protection Agency
Division of Water Pollution Control
2200 Churchill Road
Springfield, Illinois 62706

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The purpose of this report is to present and briefly interpret preliminary trends in water quality data collected from project inception thru September 30, 1981 as part of the Blue Creek Watershed project. This discussion covers seventeen months worth of data.

The primary purpose of this monitoring and evaluation project is to determine the actual yield of pollutants from a variety of agricultural practices to downstream receiving water and its effect upon the water quality and reasonable uses of the water resources. Monitoring and evaluation of actual Resource Management System implementation progress on sub-watersheds and yield of pollutants to the major tributary stream and public water supply lake will allow a reliable comparison of low and high-cost practices and downstream yield reductions, evaluation of cause and effect relationships between a variety of practices, determination of nonpoint source yields for the selection of lands requiring treatment to reduce water quality problems, and the impact of Resource Management Systems on both stream and lake quality. The observations and explanations are only preliminary in nature and should not be considered absolute conclusions.

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Water Resource Data and Trend Analysis for the Blue Creek Watershed Project, Pike County, Illinois

Phase II

Written by

Thomas E. Davenport
Project Management Unit

Planning Section

Division of Water Pollution Control
Illinois Environmental Protection Agency
2200 Churchill Road
Springfield, Illinois 62706

September, 1982

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Analyses of bacterial samples and of perishable and non-metallic chemical constituents in water samples were performed at the IEPA laboratory in Champaign, under the direction of Roy Frazier. Analyses of Kjeldahl-Nitrogen and designated metals in water samples were also performed at the Champaign laboratory. The IEPA Springfield Laboratory under the direction of John Hurley performed organic pesticide and PCB analysis of water samples.

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Executive Summary

1. Background: The Illinois Environmental Protection Agency (IEPA) in cooperation with the United States Department of Agriculture Agencies, Agricultural Stabilization and Conservation Service (ASCS), Cooperative Extension Service (CES) and Soil Conservation Service (SCS), is evaluating the impact of Resource Management Systems (RMS's) implemented under the ACP Special Water Quality Project in the Blue Creek Watershed; Pike County, Illinois. The primary objectives of this project are to identify the most viable agricultural non-point source (NPS) control strategy, demonstrate its effectiveness, develop a methodology to identify land causing water quality problems and to determine the appropriate RMS's.

2. Investigation: The physical, biological, and chemical characteristics of the Blue Creek Watershed were studied since May, 1980. A comprehensive monitoring network for the entire Blue Creek Watershed was established by IEPA to document the basic hydrological, meterological, and water quality factors of the project area during 1980. The duration, timing and quantity of NPS pollutants were evaluated to determine land management effects on the water quality/quantity budget. Methods used for field and laboratory procedures are those accepted for agricultural related hydrology research. Analytical techniques are documented, but not detailed.

3. Results: Three periods based on the amount of surface cover and land management activities, were selected for evaluating seasonal variation in streamflow constituent concentrations and transport. These periods are: P1-fertilizer and seedbed establishment period (April-June); P2-reproduction and maturation period (July-November); and P3-residue period (December-March).

   A. Land Treatment: As of October 1, 1981; 70% of the soil loss reduction goal had been achieved, erosion has been reduced by 16,495 tons/year. 60.0% of this reduction in erosion results from the application of cultural practices, the remainder results from the implementation of structural practices.

   B. Hydrology: Variability of streamflow as attributed primarily to precipitation patterns and land cover, precipitation was 17.5% above normal. High flows were measured from February through June while lower flows were measured during July and August. The rainfall-runoff ratio ranged from 4.7% to 80.1% during July and averaged 41.4% for Water Year 1981.

   C. Water Quality: Water samples were collected at seven stations in the Blue Creek Watershed (Figure 2) during Phase II of the project. There are three types of stations within the watershed; watershed stations (A, B, C) sub-basin D and field stations (E, F, J).

1. Watershed Stations: A total of 27 water quality parameters were evaluated at the three stations during Water Year 1981.

    a. Suspended Matter: Total suspended and volatile solids concentrations showed a definite "upstream-downstream" trend with lower quantities measured downstream. Suspended and volatile solids showed a definite seasonal trend where P1 (March-June) had the highest concentrations and P3 (December-February) had the lowest. These periods (P1, P2, and P3) are based on the amount of surface cover and land management activities. The percentage of total suspended solids that is comprised of volatile solids showed a definite "upstream-downstream" relationship with Station A having the highest.

    b. Turbidity: Turbidity varied between analysis periods with P1 having the highest value and P3 the lowest. The turbidity values increased between Stations C and B, and then decreased between B and A. The decrease between B and A is caused by the lake.

    c. Phosphorus: Total and dissolved phosphorus were measured. The mean 1980 and 1981 Water Year total phosphorus concentrations at Station C exceeded the USEPA recommended maximum desirable concentration of 0.1 mg/l for flowing water. Mean 1980 and 1981 Water Year total phosphorus concentrations at Station B exceeded the USEPA recommended maximum desirable concentrations of 0.05 mg/l for streams flowing into lakes and the Illinois general use standard. Mean 1981 Water Year total phosphorus concentration at Station A exceeded the USEPA recommended value. There is a distinct "upstream-downstream" trend in total phosphorus concentrations during all periods of analysis. Station C had the highest values and Station A the lowest. The significant difference between Water Year concentrations at all three stations results from the 41.3% increase in precipitation.

    d. Total Kjeldahl Nitrogen: Total Kjeldahl nitrogen concentrations exhibited a definite "upstream-downstream" trend, with Station C having the highest values and Station A the lowest. The Water Year differences are due to the precipitation difference. The land treatment activities could impact upon total Kjeldahl nitrogen concentrations due to increased amount of residue available for transport and leaching.

e. Organic Nitrogen: Organic nitrogen showed trends similar to total Kjeldahl nitrogen.

f. Nitrates-Nitrites: There was a definite "upstream-downstream" trend in nitrates-nitrites concentrations. Station C has the highest value and Station A has the lowest. Nitrate-nitrite concentrations decrease from P1 to P2 and then increases from P2 to P3.

g. Ammonia: Ammonia concentration showed similar trend to N32 concentrations.

h. Fecal: The fecal coliform/fecal streptococcus ratios indicates wastes of mixed human and animal sources.

i. Potassium: Potassium concentrations did not show a definite pattern over the Water Years 1980 and 1981.

j. Organic Matter Demand: Chemical oxygen demand and biological oxygen demand are used to estimate the total quantity of organic matter present. Mean BOD values at Station B were the highest of three stations during Water Years 1980 and 1981, this result from the flow construction device (bridge) there. Mean COD values showed a definite "upstream-downstream" trend during Water Years 1980 and 1981. Mean COD values were higher at all three stations during Water Year 1981 in comparison to Water Year 1980. COD values are significantly higher than BOD values.

k. Heavy Metals and Trace Elements: 20 parameters were evaluated during Water Years 1980 and 1981. None of these were in quantities so as to indicate a water quality problem.

m. Dissolved Oxygen: Dissolved oxygen values were the lowest at Station B. This results from the high biological and chemical oxygen demand at this site.

n. Runoff and Suspended Solids Transport: Eleven storms during Water Year 1981 account for 73% of the total suspended solid load transported by Station C.

o. Loadings: 94 percent of the sediment load transported by Station C within 6% of the year during Water Year 1981. The majority of total suspended solids transport occurs during P1 (98%). Total suspended solids transport shows a definite "upstream -- downstream" trend with lower quantities measured downstream.

p. Sediment Delivery Ratio: The sediment delivery ratio for the watershed from 1974 to 1979 is 38 percent (from 1961-1979, 66 percent). The sedimentation rate from 1974 to 1979 is 0.64 percent as compared to 1.24 percent from 1961 to 1974.

2. Sub Basin Water Quality Stations: Only one sub-basin within the watershed is being monitored and it is sampled on event-runoff basis.

   a. Suspended Material: Mean total suspended and volatile solid concentrations were higher at the sub-basin station than any of the stream stations. Total suspended and volatile solid concentrations exhibited a distinct seasonal pattern, P1's values were higher than P2's. This seasonal trend results from the interrelationship between surface cover and the precipitation pattern.

   b. Total Kjeldahl Nitrogen: Total Kjeldahl nitrogen concentrations were higher during P1 than P2.

   c. Organic Matter Demand: Chemical oxygen demand exhibited a definite seasonal trend with higher values during P1 than P2.

   d. Total Phosphorus: All total phosphorus concentrations collected exceeded the Illinois general use standard and the USEPA recommended value.

3. Field Site Monitoring: There were three field sites sampled only on event-runoff basis during Water Year 1981. Runoff from cropland is monitored at Stations E and F. At Station J runoff from a vegetative filter strip is sampled.

   a. Suspended Matter: Stations F and J's mean total suspended solid concentrations were approximately 10 times higher than Station E's during P2, this is related to ground cover differences.

   b. Total Kjeldahl Nitrogen: Mean total Kjeldahl nitrogen concentrations significantly decreases from P1 to P2 at Station E. The field stations mean total Kjeldahl concentrations were less than those measured for the sub-basin.

   c. Organic Matter Demand: All three field stations' mean chemical oxygen demand values are lower than the sub-basin station.

d. Total Phosphorus: All total phosphorus concentrations determined for the field stations exceeded the Illinois general use standard.

e. Effectiveness of Land Treatment on the Field Sites: The vegetative filter strip has reduced the potential pollution level of a feedlot so it is equivalent to that of a drainage area, that is managed so as to conform to the State mandated "T" value, for all parameters except total phosphorus.

4. Lake Water Quality: Pittsfield City Lake has been sampled since 1979.

a. Turbidity at Water Treatment Plant's: Mean monthly turbidity values in water taken from Pittsfield City Lake since 1976 have been increasing. There are definite seasonal trends, these result from the normal precipitation and land management activity patterns for the watershed. Higher turbidity values occur during the spring and lower values are measured in late summer and early fall.

b. Lake Water Quality: There were obvious seasonal and spatial trends exhibited by several parameters (Secchi, NTU's, TSS, TVS, N32, PTL, DSP, FC and COD). Water clarity generally increased from the lake inflow to the dam. The lake quality as indicated by water clarity responded to storm events and generally improved from April through November. The total nitrogen to total phosphorus and the inorganic nitrogen to dissolved phosphorus ratios indicate that the amount of phosphorus present limits the utilization of all the nitrogen present.

c. Lake Classification: Based upon total phosphorus and Secchi values classification system, developed during the 1973 National Eutrophication Survey, Pittsfield City Lake would be considered eutrophic.

d. Trophic State Index: The trophic state index fluctuated with rainfall. The lower the trophic state index value the less eutrophic the lake. The 1980 value was the lowest.

Introduction

The Illinois Environmental Protection Agency (IEPA) in cooperation with United States Department of Agriculture Agencies, Agricultural Stabilization and Conservation Service (ASCS), Illinois Cooperative Extension Service (CES) and Soil Conservation Service (SCS), is evaluating the impact of Resource Management Systems (RMS's) implemented under the Agricultural Conservation Program-Special Water Quality Project in the Blue Creek Watershed, Pike County, Illinois. The primary objective of this project is to identify the most viable agricultural non-point source (NPS) control strategy, demonstrate its effectiveness, and develop a methodology to identify land causing water quality problems and to determine the appropriate Resource Management System for the identified land. The purpose of this report is to present and interpret preliminary trends in the water quality data collected from project inception thru November 31, 1981 as part of the Blue Creek Watershed Project.

Description of Blue Creek Watershed

The Blue Creek Watershed encompasses 7,012 acres in east central Pike County, Illinois. It drains into Pittsfield City Lake through Blue Creek and its numerous tributaries (refer to Figure 1). The Blue Creek Watershed is located approximately three miles northwest of Pittsfield and five miles south of Griggsville.

Pittsfield City Lake was constructed in 1961 by the Soil Conservation Service as a multiple purpose reservoir. It is utilized for recreation, flood control and as a water supply for the City of Pittsfield. There are no known municipal or industrial discharges to the Blue Creek Watershed upstream from Pittsfield City Lake.

The land use in Blue Creek Watershed is predominantly agricultural (Table 1). The cultivation of row crops and production of livestock are important in the watershed. The predominant crop in the watershed is corn (47.7 percent of the acreage in cropland). Soybeans, wheat, and grasses are also important crops. The terrain is hilly, and it has a high soil loss potential due to its steep slopes, fine-textured soils and agricultural land use practices. There are approximately 460 acres of hog and cattle feedlot operations on 21 farms.

For a more detailed description of Blue Creek Watershed and Pittsfield City Lake refer to Blue Creek Watershed Project, May 1979-October, 1980, (Davenport, 1981).

Purpose of Special Monitoring and Evaluation

The primary purpose of the monitoring and evaluation project is to determine the actual yield of pollutants (resulting from a variety of agricultural practices) to downstream receiving water and its resulting effect upon the water quality and reasonable uses of the water resources.

TABLE 1

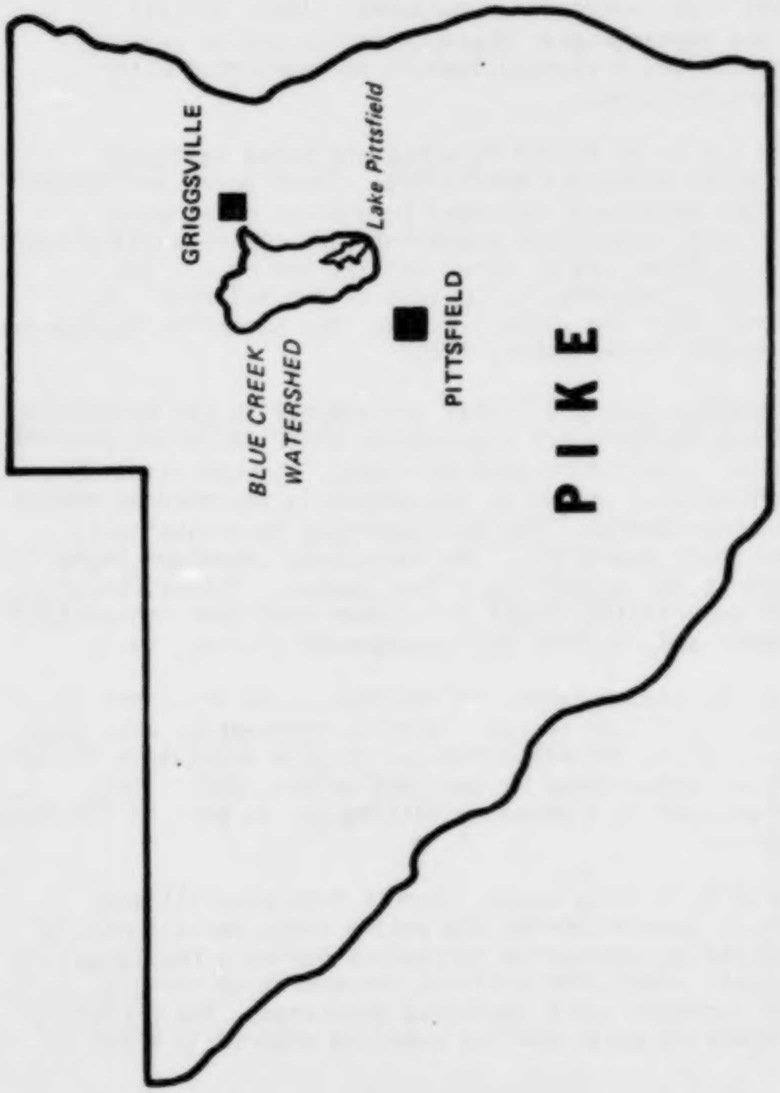
Land Use and Crop Distribution in the Blue Creek Watershed as of October 1, 1980 in acres (Davenport, 1982).

Land Use/ Cover	Blue Creek Watershed # of Acres	%
Cropland		
Corn	1890.1	(47.7)
Soybeans	853.2	(21.5)
Small Grains (Wheat)	368.0	(9.3)
Meadow	849.5	(21.5)
Subtotal	3960.8	56.4
Pasture/Hayland*		
80% cover	731.3	(48.1)
95% cover	788.0	(51.9)
Subtotal	1519.3	21.7
Woodland		
Managed	543.6	(67.1)
Unmanaged**	266.4	(32.9)
Subtotal	810.0	11.6
Other		
Wildlife	311.7	(43.1)
Farmstead	109.1	(15.1)
Feedlot	65.5	(9.1)
Water	236.4	(32.7)
Subtotal	722.7	10.3
TOTAL	7012.8	

*Includes grass waterways.
**Livestock grazing permitted.

Monitoring and evaluation of actual RMS's implementation progress on sub-watershed and yield of pollutants to the major tributary stream and public water supply lake will allow a reliable comparison of low and high-cost practices and downstream yield reductions. Evaluation of cause and effect relationships between a variety of practices, determination of NPS yields from farmlands requiring treatment to reduce water quality problems, and assessment of the impact of RMS's on both stream and lake quality.

Figure 1. Blue Creek Watershed, Pike County, Illinois


GRIGGSVILLE
Lake Pittsfield
BLUE CREEK WATERSHED
PITTSFIELD
PIKE

Monitoring Strategy

The comprehensive monitoring network for the entire Blue Creek watershed was established by IEPA to document the basic hydrological, meterological and water quality factors of the project area (Figures 2 and 3). The duration, timing and quantity of NPS pollutants are being evaluated to determine land management effects on the water quality/quantity budget. The main stem of Blue Creek is monitored at two locations (Stations C & B) representing 50 and 70% of the drainage area respectively. One direct tributary (Station D) to the lake is monitored to determine the relative contribution of a major sub-basin directly entering the lake and provide data for unit size contribution purposes. Thus, spatial patterns, land use and physiographic characteristics can be evaluated relative to their actual and projected impacts on downstream water quality and lake characteristics.

Two fields (Stations E & F) of 40 and 79 acres are being monitored concurrent with the major tributary monitoring. These areas are natural drainage networks. The areas were selected to provide comparative information on field level conditions representative of the physiography and land use activities impacting on water quality and uses. The sub-basin sites provide a comparative analysis of two different soil types, land management (RMS) and slope classes. The base-line monitoring of the sub-basins started in September, 1980.

Not all livestock feedlots within Illinois are subject to the permitting program. Some of these feedlots are a potential water pollution problem because of uncontrolled runoff from open lot areas. Installation of a zero discharge runoff-control system is the presently recommended method of solving this pollution threat. But this approach is economically prohibitive for many small operations. An innovative technique being looked at in Illinois is the vegetative filter system. This alternative has the advantage of controlling runoff at a lower cost than conventional zero-discharge systems, and requires less management (Dickey, 1981).

The SCS designed and assisted a farmer in the Blue Creek Watershed in constructing a vegetative filter system. IEPA in cooperation with ISWS was interested in evaluating the effectiveness of this vegetative filter strip, so Station J was established by the ISWS in May, 1981. This filter strip is not managed in a research setting but as part of the land owner's normal operation.

Streamflow is measured on a daily basis. Runoff from rainfall and snowmelt is intensively sampled during the entire event because most of the sediment transported by streamflow is carried during a few large storms. During a runoff event, the sediment concentration usually changes abruptly and increases with increased discharge. The frequency and timing of the intensive water quality sampling program is keyed to storm events.

The lake is monitored at three locations to determine water quality and subsequent impacts of RMS's implementation (Figure 4).

The biological, stream geometry and channel characteristics, and computer-based modeling components of the Blue Creek Monitoring Program are described in the "Blue Creek Watershed Project, Pike County, Illinois May, 1979 -- October, 1980" report.

Description of Monitoring Stations

Descriptions of the individual monitoring stations are presented below. Refer to Figure 2 for the location of the monitoring stations.

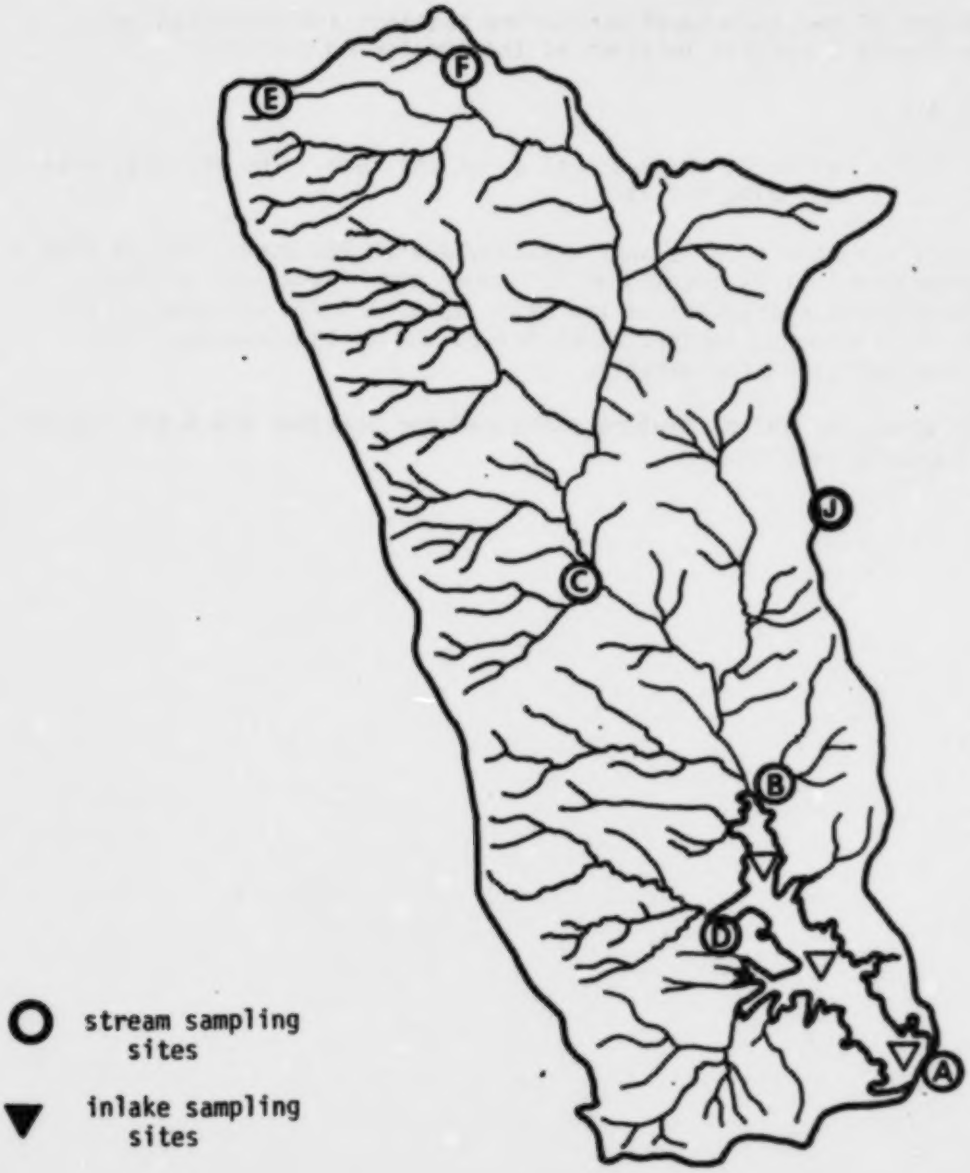
Stations A & B

Station A, the spillway, samples outflow of the lake. The drainage area is 7,029 acres including the lake.

Station B's drainage area is approximately 70% (4,858 acres) of the Blue Creek Watershed. It is located at the upper end of the lake on Blue Creek, this point characterizes the major lake inflow. Upstream of the causeway at Station B, sedimentation occurs due to the causeway flow restriction and backwater effects.

Sampling schedules and parameters monitored for Stations A & B are listed in the Appendix Section.

Figure 2. Map of Water Quality Stations in the Blue Creek Watershed in Pike County, Illinois


E
F
J
C
B
D
A
○ stream sampling sites
▼ inlake sampling sites

Station C

Station C is located at the Highway 107 bridge crossing Blue Creek. The most comprehensive sampling in the project area was conducted at this site. Streamflow is measured at Station C. Sampling frequency is daily, weekly and event related.

This sub-watershed drains approximately 50% (3,339 acres) of the Blue Creek Watershed. Land use by acreage in this sub-watershed is presented in Table 2. In general, the relative proportion of each use is similar to the overall land use in the entire project area. Pasture and cropland comprise nearly 80 percent of the use with over two-thirds of the total in row crop production. 12.7% of the agricultural land has had conservation applied to it. Feedlot acreage is listed both under the woodland and farmstead land use category depending upon the type of operation.

TABLE 2

Land use by acreage for the watershed drainage area to Station C in the Blue Creek Watershed as of October 1, 1981.

Land Use	Acreage	Percent Total
Cropland	2006	60.0
Pasture/Hayland	768	23.01
Woodland	288	8.6
Wildland	196	5.9
Farmstead	33	1.0
Feedlot	48	1.5
Total	3339	100

Station D

Station D is located on the western side of Pittsfield City Lake. Runoff resulting from rainfall-events and snowmelt is sampled at Station D. Parameters monitored are listed in the Appendix Section.

Land use in the lowlands is predominately woodland and pasture with rowcropping dominant on the sloping lands and ridgelands (Table 3). There are three feedlot operations in this sub-basin. The drainage area of this sub-watershed is 470 acres. It drains directly into the lake.

TABLE 3

Land use by acreage for the sub-watered drainage area to Station D in the Blue Creek Watershed as of October 1, 1980.

Land Use	Acreage	Percent Total
Cropland	248	52.7
Woodland	142	30.2
Pasture	80	17.1
TOTAL	470	100

Station E*

Station E is located in the northwestern part of the watershed. Runoff resulting from rainfall-events and snowmelt is sampled at Station E. The parameters monitored are listed in the Appendix Section.

Station E consists of one 40-acre field draining into an unnamed channel. Table 4 lists the past practice, present practice and the average annual erosion rate by practice. The present practice has reduced average annual erosion by 40%. This soil loss is still approximately 3 times the allowable maximum soil loss per acre tolerance loss (T) a given soil may experience and still maintain its productivity over an extended period of time as defined by the Soil Conservation Service.

*Station E originally was located in the southwest part of the waterhshed, but due to monitoring difficulty it was moved to its present location.

TABLE 4

Past practice, present practice and the associated average annual erosion rate by practice for Station E's drainage area.

SIZE (acres)	$\bar{X}$ ANNUAL EROSION RATE* (TONS/ACRES)	PAST PRACTICE
40	24 Tons	C-Sb Rotation Spring Plow Up & Down the Slope
		PROPOSED PRACTICE
	14.5	C-Sb-6r Rotation Chisel Plow in the Fall Disk Twice & Plant; 1-2000 lbs. Residue Left on the Ground

*Calculated using the USLE C; Corn, Sb; Soybean, Gr; Wheat

Station F

Station F is located in the northern part of the watershed. Runoff resulting from rainfall events and snowmelt is sampled at Station F. The parameters sampled are listed in the Appendix Section.

Drainage area of Station F consist of 79 acres draining four different fields. Table 5 lists the past and proposed practices and the average annual erosion rate by practice for each field. The implementation of proposed practices will reduce average annual erosion by 77%. The resulting soil loss is below the maximum allowable soil loss tolerance per acre (T).

TABLE 5

Past practices, proposed practices and the associated average annual erosion rate by practice for fields in Station F's drainage area.

FIELD NUMBER	SIZE (acre)	$\overline{X}$ ANNUAL EROSION RATE* (TONS/ACRE)	PAST PRACTICES
#2	14.6	19-20	C-Sb Rotation Spring Plow Across the Slope or Disk - Chisel - Disk Twice - Plant
#3	19.8	10-11	C-Sb-Gr-4 yrs. Grass Rotation - Spring Plow Across the Slope
#4	34.1	19-20	C-Sb Rotation Spring Plow Across the Slope or Disk - Chisel - Disk Twice - Plant
#5	10.0	30-33	C-Sb Rotation Spring Plow Across the Slope or Disk - Chisel - Disk Twice - Plant
			PRESENT PRACTICES
#2	14.6	4.5-5.0	C-S b-Gr Rotation Conservation Tillage 1-2,000 lbs. Residue on Contour
#3	19.8	3.5-4.5	C-Sb-Gr-7 Yrs. Grass Rotation - Conservation Tillage 1-2,000 lbs. Residue on Contour

FIELD NUMBER	SIZE (acre)	$\overline{X}$ ANNUAL EROSION RATE* (TONS/ACRE)	PRESENT PRACTICES
#4	34.1	4.5-5.0	C-Sb Rotation Conservation Tillage 1-2,000 lbs. Residue on Contour
#5	10.0	4.5-5.0	C-Sb Rotation Conservation Tillage 1-2,000 lbs. Residue on Contour with Grassed Back Slope Terrace

*Calculated using the USLE C; Corn, Sb; Soybean, Gr; Wheat

Station J

Station J is located due west of Station C. Runoff resulting from rainfall events and snowmelt is sampled at Station J. Station J was established in May, 1981.

Drainage area of Station J consists of 4 acres draining an animal (hog) feedlot and a vegetative filter system. The feedlot area is 2 acres and the vegetative filter system area is 2 acres. This vegetative filter was designed according to National SCS Standards. The vegetative filter strip combines the processes of infiltration, dilution, and filtration to control runoff from the feedlot so that violations of water quality standards will not occur during storm runoff. Feedlot holds a maximum of 275 hogs. It was estimated that annual gross erosion on feedlots averaged 35 tons/acre within the watershed (Davenport, 1982).

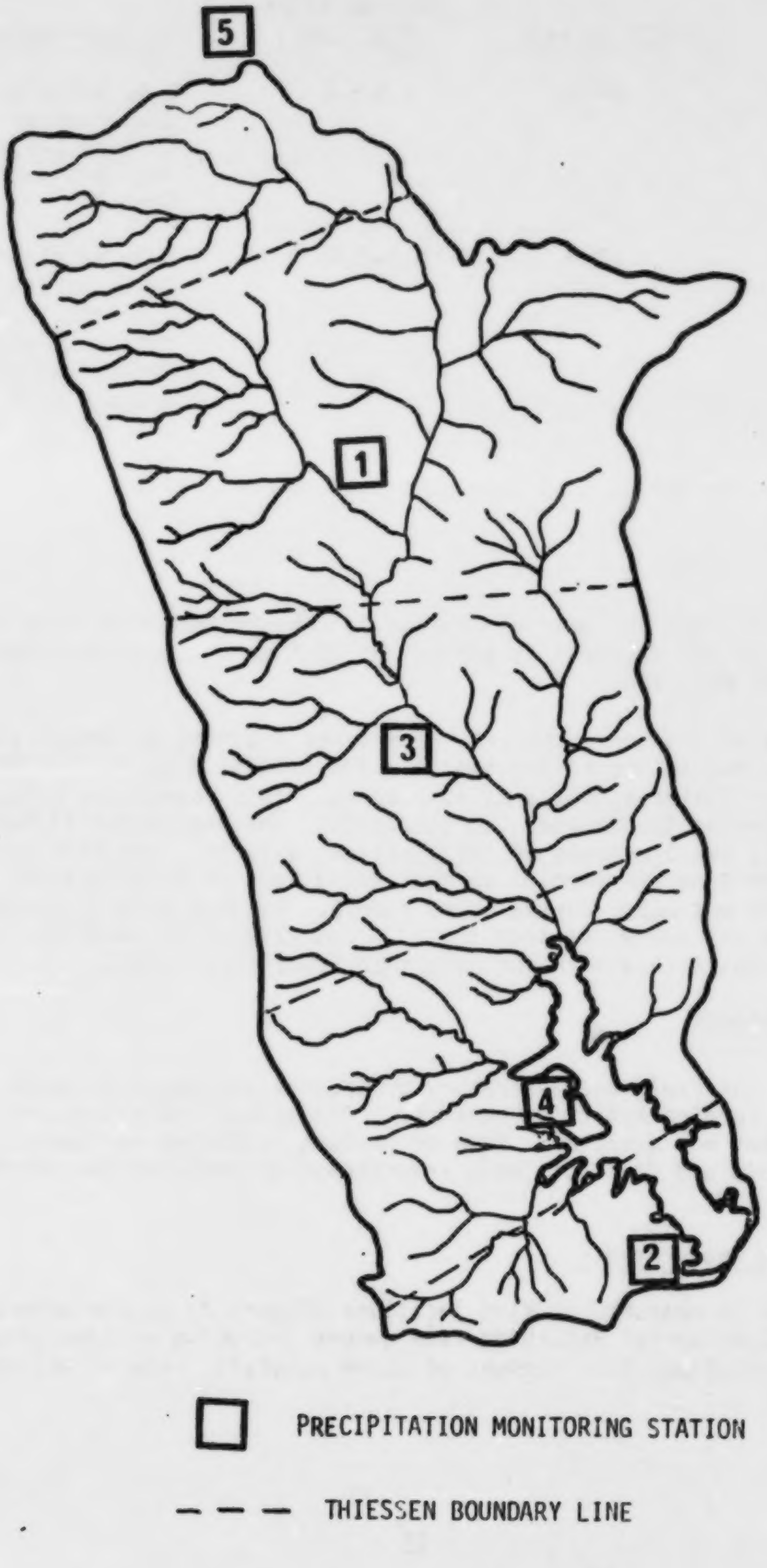
Monitoring Methods

Methods used for field and laboratory procedures are those accepted for agricultural related hydrology research. Analytical techniques are documented, but not detailed. Name of product is listed for benefit of the reader only and does not imply endorsement or preferential treatment by the IEPA.

Precipitation Measurements

Precipitation is measured at five locations (Figure 3) on the watershed using Belfort Universal Recording rain gauges (weighing -- type gauge). Annual precipitation, total amount of storm rainfall, rate of delivery,

Figure 3. Location of Precipitation Monitoring Stations Within the Blue Creek Watershed.


5
1
3
4
2
PRECIPITATION MONITORING STATION
THIESSEN BOUNDARY LINE

duration and distribution in time and space are directly measured or calculated. For annual precipitation, the values of all five rain gauges are averaged. The individual station records are utilized when determining storm variation for soil erosion/sediment delivery calculations and modeling. Two methods are utilized when analyzing storm variation, these methods are depth-area-duration and storm frequency analyses.

A depth-area-duration analysis is used to determine the maximum amounts of precipitation for storms of various durations distributed over various parts of the watershed. The storm frequency analysis is used to determine the frequency with which a storm of a certain magnitude will be equaled or exceeded. It was necessary in the design of structural RMS's to know the frequency with which storms of a given size and intensity will be equaled or exceeded. When evaluating the effectiveness of individual RMS's, the storm frequency of the measured storm must be determined to see if it exceeded the design storm.

Flow Measurements

There are four automated flow gauging stations installed in the Blue Creek Watershed. The two major streamflow gauging Stations (C & D refer to Figure 2) consist of stilling wells, (diameter; Station C, 24 in.; Station D, 18 in.) and a Leupold Stevens continuous water level recorder. The stilling well is a corrugated pipe installed to a level below the river bottom and connected to the river flow by underground pipes. The stage in the river is the same as the elevation of the water in the corrugated pipe (stilling well), which is recorded by the Leupold Stevens recorder. The river banks and channel are undisturbed. The remaining two automatic stations are field runoff gauging stations (E & F) each have a 3.0' H-Flume and a watch-dog type Leupold Steven water level recorder. These Leupold-Stevens instruments record the level (stage) of runoff continuously on a strip chart after being activated. Flumes were needed at these locations to enable highly accurate runoff estimates. A flume is a device for controlling the flow by keeping the water moving for some distance in a constant cross-sectional area. These flumes were designed to minimize the errors in determining the relation of runoff to stage. Leupold Stevens' strip charts are digitized by the Illinois State Water Survey (ISWS) under the direction of Ming Lee for subsequent analysis.

To record maximum streamflow during runoff events crest gauges have been installed at five locations on the main stem of Blue Creek. The highest water level leaves a mark on the gauge that the field sampler records when collecting stream bed samples for analysis after runoff events. Only the highest streamflow leaves a mark.

Blue Creek was surveyed and channel cross-sections of the stream were made. Using the Soil Conservation Service's WSP2 Computer Program, a stage-discharge relationship was developed. Several cross-sections had to be taken downstream of Station C because no stage-discharge relationships were known. The water surface profile calculations began at critical depth and since the calculations began downstream, the stream channel geometry would govern the flow regime so that by Station C the stage should be reasonably close to the actual stage for a particular discharge. Lake Pittsfield's influence may be felt at Station C so therefore, a refinement was in order. With the results from the first run of the computer program as a starting point, a second computer run was made. The resulting stage-discharge was then calibrated. The calibration was done by comparing the monthly runoff at Station C computed using the stage-discharge relationship obtained from WSP2 with the runoff at Bay Creek. Various ratios of the stage-discharge relationship were used until there was agreement between the discharges at Station C and at Bay Creek. The stream stage level was continuously measured starting in November, 1979 at Station C.

There were no stage measurements made at Station B. It was then necessary to find a method to determine discharge at this site in lieu of any stage measurements. It was felt that Station B must be related to one or both of the other two stations. Station A may not be representative due to pumpage, evaporation and direct rainfall on the lake. Therefore, Station B was related to Station C in the analysis. The relationship that was used was the ratio of drainge areas and runoff.

Discharge @ B = Discharge @ C* Drainage Area @ B/Drainage Area @ C

Though Station C had hourly readings, only daily averages were used which minimized any errors.

Daily stage readings were recorded at Station A. Knowing the geometry of the spillway, a stage-discharge relationship was calculated. The instantaneous stage reading was assumed to be a daily average since the lake stage response is so slow. (Makowski, ISWS, personal communication). At Station D, direct streamflow measurement is not feasible. The site has three parallel 66-inch corrugated pipes. Because of this situation a United States Geological Service indirect method will be utilized to estimate stream discharge. Station D was fully operational as of October 1, 1980. At stations E and F, the flumes are rated 30' H-Flumes as such, the discharge hydrographs (discharge is plotted over time the resulting curve is a hydrograph) can be estimated directly from published rating curves and recorded stage data. Stations E and F became operational in September, 1980. Station J became operational in May, 1981.

Field methods used in this study are a recognized compromise between the accuracy and precision of field sampling and the funds available for the study. Generally, estimations of streamflow using uncontrolled sections of channel have an accuracy of about ± 10%. When flood events occur which are significantly greater than any measured streamflow, the accuracy of estimation of peak flow is unknown. As flow durations of extreme flood events are short, the overall accuracy of a water balance is much better than prediction of short-term peak flows.

Watershed Water Quality Sampling

Water quality monitoring was initiated in May, 1980. Five ISCO automatic water samplers (model 1680) and one Sigma automatic device sampled streamflow during runoff events. The ISCO samplers were located at gauging Stations C, D, E, F and J. At stations C and D, the samplers were programed to collect 250 millimeters (ml) of streamflow each 7 1/2 minutes compositing two samples per bottle. Each sampler would collect 7

1/2 minute samples for a 7-hour period once started. At Stations E, J, & F, the samplers were programed to collect 250 ml of streamflow each 7 minutes, compositing two samples per bottle. Each sampler would collect 7 minute samples for a 6.5 hour period once started. The Sigma sampler was located next to the dam spillway (Station A) to sample lake outflow resulting from storm or snowmelt events. Due to mechanical problems, Station A is now sampled manually twice a day for six days after rainfall events.

Electrical triggering devices initiates sample collection by activating each automatic water sampler when the water level reached a predetermined stage which varied by location and season. Stages were selected which would allow the complete runoff event at that location to be sampled. However, the duration of some runoff events exceeded the sampler capacity or mechanical problems with the sampler, prevented sampling of the complete hydrograph.

Weekly, daily and monthly samples at Stations A, B, and C were collected using a hand-held bottle or weighted bottle holder as appropriate, and composited in a churn sample splitter in accordance with established IEPA procedures (Walton, 1979).

Samples collected by the ISCO automatic water sampler are drawn by a peristalic pump through 1/4 inch, (I.D.) tygon tubing that extends from each sampler to the thalweg (deep spot) of the stream course being sampled. Before and after the sample is taken, the pump air purges the suction line, thus minimizing the possibility of cross section contamination. The weighted polypropylene strainer at the end of each suction line is suspended into the stream from an overhead guiding device.

A major drawback of the suspended sediment sampling procedure is that they do not permit sampling close to the streambed. Currently available suspended-sediment samplers only collect water samples from the surface to a point about 0.3 to 0.5 feet above the bottom. These samplers and sampling procedures do not allow the sampling of the layer of streamflow closest to the bottom which is carrying the greatest concentration of coarse particles (bedload). Therefore, bedload is not measured as part of the water quality monitoring. As part of the stream geometry and channel characteristics study (Davenport, 1981), particle size distribution analyses of bed material at five sites in the main channel of Blue Creek enables the contribution of bed material to the total suspended load to be estimated.

Water samples sent to the laboratory for routine analyses were collected in plastic bottles with appropriate preservative (Appendix Section). Pesticides and polychlorinated biphenyls (PCB's) samples were collected with specially prepared quart bottles using methods described above and composited directly into a one-gallon glass bottle. Fecal coliform samples were collected in specially prepared glass bottles.

Dissolved oxygen, temperature, pH, and conductivity were measured using a Hydrolab 4041 digital meter in the field. The meter is calibrated in the field consistent with the Agency Field Methods Manual (Walton, 1979).

Lake Water Quality Sampling

Ambient lake water quality is the result of a complex of possible interactions between numerous physiochemical, environmental, and biological constituents, all of which may vary in a spatiotemporal manner. "Fundamental data used in the determination of water quality are obtained by the chemical analysis of water samples in the laboratory or on-site sensing of chemical properties in the field (Hem 1979)." An ambient water quality data base is an essential prerequisite to evaluating the impact of RMS's upon lake water quality, developing rational lake or reservoir management strategies. Of necessity, an acceptable data base should include (but not necessarily be limited to) an assessment of the following types of in-lake parameters:

1. Nutrients, physical, and chemical factors that may limit, inhibit, or stimulate plant growth;

2. Factors which affect water transparency and, thus, primary production rates;

3. Extent and degree of vertical stratification and those constituents whose solubility is affected by changes in redox potential;

4. Potential toxic contaminants such as heavy metals, organochlorine compounds, etc.

Field Collection (IEPA, 1980)

Lake sampling was routinely accomplished by boat with a team of two people. Sampling locations were selected to best represent overall lake quality and were based upon lake morphometry, potential input sources, known hydrological characteristics and on-site judgment of the investigators. Three sites were sampled on Pittsfield City Lake.

Chemical and physical measurements made in the field included pH, alkalinity, conductance, water transparency (Secchi), dissolved oxygen, temperature, and site depth. Observations of the weather conditions including air temperature, wind speed and direction, precipitation, and percent cloud cover were recorded on field data forms. Lake color (apparent color), turbidity, aquatic flora, water levels, and general lake usage were noted as appropriate.

Water transparency was measured with an eight-inch-diameter Secchi disc. The disc was lowered until it disappeared from view and the depth of immersion was noted. The disc was lowered further and then raised slowly until it reappeared. This depth was noted. The average of these two observations was recorded as the Secchi disc transparency. Site depth was determined using a weighted line calibrated in feet with results estimated to the nearest tenth of a foot.

Water samples were collected at the top of the water column (approximately one foot below surface) and two feet above the bottom when site depth exceeded ten feet. All water samples, except mercury and bacterial, were collected with a 4.2-liter plastic Kemmerer water sampler. Top water samples were taken by immersing the open sampler in the horizontal position to a depth of one foot and closing by hand. When required, bottom samples were taken by triggering the sampler in the conventional manner. All water samples collected by the Kemmerer, with the exception of water destined for dissolved phosphate analysis, were placed in ice, and taken to the laboratory for analysis. Dissolved phosphate water samples were first filtered through 0.45 um pore size Type MF-Millipore filters. Mercury and bacterial samples were collected from surface waters by hand-held bottles.

The pH of water samples was determined using a Hydrolab 4041 meter. Alkalinity was determined from titration of a 10 ml sample with 0.02 NH_2SO_4 using phenolphthalein and bromcresol green-methyl red indicators. Results were expressed as mg/l $CaCo_3$. Air temperature was taken with a mercury-type field thermometer. Water temperature, pH, dissolved oxygen concentrations and conducting were taken in situ using a Hydrolab 4041 digital meter; measurements of DO and temperature were taken at the surface, one foot below the surface, and at two-foot intervals thereafter (i.e., 3 ft., 5 ft., 7 ft., etc.) and discontinued beyond depths which recorded 0.0 mg/l dissolved oxygen. The Hydrolab 4041 meter were all calibrated in the field in accordance with IEPA sampling procedures (Walton, 1979).

Laboratory Procedures (IEPA, 1980)

Upon return to the regional field office, samples were refrigerated or frozen and transported to the appropriate lab for analysis. Table in the Appendix Section, lists all parameters monitored, the laboratory performing the analysis, and provides a brief outline of the specific analytic procedure used in each analysis. Other pertinent information such as detection limits and General Use Standards are also included.

Data Management

All watershed water quality/quantity information is entered into the University of Illinois data management system, located in Champaign, Illinois by ISWS. All lake quality information is entered into the USEPA "STORET" system. The turbidity data from the Pittsfield Water Treatment Plant has been entered into IEPA Tektronix data management system.

Data Analysis

Data analysis is the translation or distillation of measurements via statistical and (or) graphical techniques into information needed to solve problems or make interpretation of observed events. Two methods were used in analysis and interpretation of the data these were: curve fitting/trend analysis, and hypothesis testing.

The curve fitting/trend analysis technique used was linear regression. This method smooths out the inherent variability in the data and expose the underlying trend if one is present. In the final analysis the resulting linear regression equation will be used to estimate the future values of the water quality parameters.

Hypothesis testing is concerned with making decisions concerning a hypothesized value of an unkown population parameter. The Student's T test was the test utilized in hypothesis testing. There are three basic assumptions involved in the use of the test: (1) a normally distributed population for the parameters of interest, (2) the samples are randomly selected, and (3) variances of the population from which the sample sets are drawn are equal. (Kleinbaum, 1978)

RESULTS AND DISCUSSION

Quality of water refers to the properties of water that influence its use and is defined by its physical, optical, biological and chemical properties and characteristics. Water media includes the natural properties of water as well as the suspended and dissolved materials affecting these properties and its appearance, use and capability to sustain biological life. Suspended solids are of particular concern because they have direct effects on water suitability for various uses and because they may influence other characteristics such as odor and color.

The water quality measures used in the Blue Creek project are:

1. The concentration of parameters, e.g., suspended solids, total phosphorus, and nitrates, measured in mass/unit volume.

2. The watershed yield or load of these parameters, measured in mass rate of flow/unit time.

The concentrations of streamflow constituents in water as it flows downstream directly affects aquatic life. On a long-term basis, the watershed yield or load determines the amount of pollutants contributed to a lake or river downstream.

Water quality sampling in the Blue Creek Watershed started in May, 1980 and continues to the present. Streamflow samples are collected on a daily, weekly, monthly and a storm event bases. All laboratory analyses were performed by Illinois Environmental Protection Agency's laboratories. All water quality data is presented in the Appendix Section. This discussion covers approximately 18 months of data. The observations and explanations are only preliminary in nature and should not be considered absolute conclusions. All reference to standards or concentration levels not specified as being set by the Illinois Pollution Control Board are values that are recommended in the literature and have no legal basis.

Three periods, based on the amount of surface cover and land management activities, were selected for evaluating seasons and variation in streamflow constituent concentrations and transport. These periods were selected to conform to the normal agricultural management pattern of the watershed. These periods are: P1-fertilizer, seedbed, and establishment period (April-June); P2-reproduction and maturation period (July-November); and P3-residue period (December-March). There will be some variation in period length from year to year due to climatic factor.

WATERSHED

The watershed section is divied into four sections; 1) general watershed information, 2) stream water quality, field runoff water quality runoff, 3) stream water quality and 4) loadings.

Land Treatment

RMS's are being developed by SCS to meet the goals of the project and concerns of the people. The Blue Creek Special Water Quality Project is an ASCS cost-share program that assists farmers in installing conservation practices to protect the resource base and improve water quality. A land owner/operator has three options to reduce soil loss: (a) employ erosion control practices; (b) switch to rotations that have lower soil loss; or (c) convert cropland to pasture. Approvals for 1981 fiscal year of annual practices was substantial, amounting to $103,165, long-term agreements approved amounted to $53,337. The SCS is working with landowners to control erosion and also with livestock producers to control problems from waste runoff and erosion associated with livestock operations.

Initially; $403,000 were allocated to the Blue Creek ACP Special Water Quality Project. $89,055 of the initial $403,000 cost share allocation was turned back to ASCS National Office. The initial projected reduction in soil loss was 30,240 tons from implementation of practices funded thru the $403,000 allocation. This initial goal must be adjusted according to the reduced funding level, the new goal is 23,587 tons.

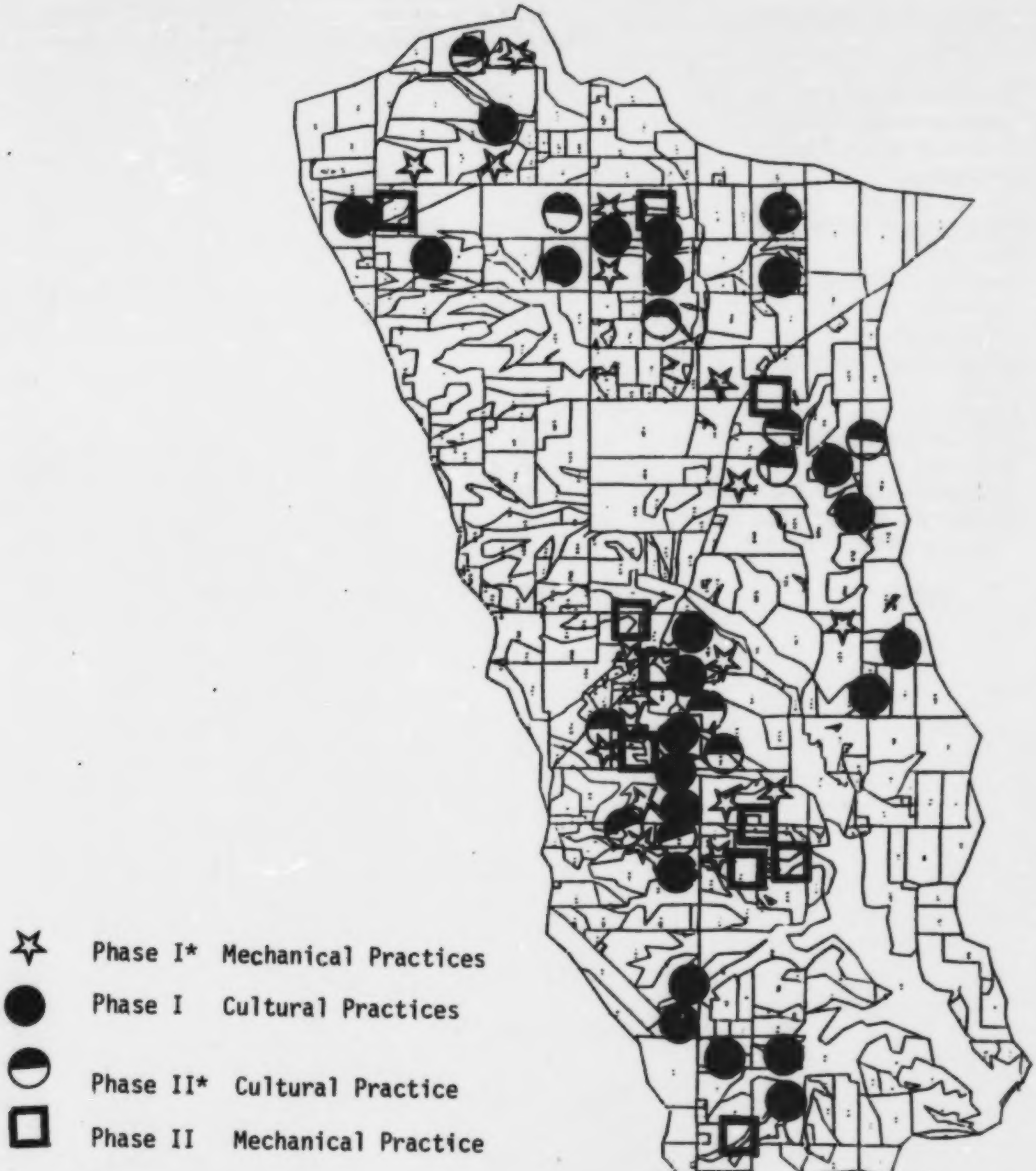
Majority (72.9%) of conservation practices installed as of October 1, 1981 were applied southeast of Highway 107 (Table 6, Figure 4). 27.9% of the area southeast of Highway 107 is under land treatment while only 10.5% of the remaining 3339 acres has had treatment applied. Low prices, during Phase II, for most agricultural products hindered land treatment efforts. Land owner/operator interest remained high. Fourteen acres of feedlot operation have been treated since project inception.

TABLE 6

Summary of conservation practices applied in the Blue Creek Watershed in relation to Highway 107 (Station C).

Conservation Practice	Southeast of Highway 107 Acres Treated		Northwest of Highway 107 Acres Treated	
	Phase I	Phase II	Phase I	Phase II
Critical area seeding and pasture improvement	32	0	0	0
Critical area seeding	0	0	3	0
Contour	172	67	78	0
Stripcropping	43	0	0	0
Contour strip-cropping	0	15	0	0
No-till	146	36	71	0
Reduced tillage	0	0	31	0
Terraces	178	70	4	54
Structures	64	21	0	0
Streambank Protection	0	13	0	0
Pond	1	0	0	0
Lagoon	0	0	2	5
Vegetative Filter Strip	4	4	0	0
Waterway	29	3	51	40
Permanent Cover Improvement	0	14	0	0
Permanent Vegetative Cover	0	25	12	0
Pasture establishment	0	7	0	0
TOTAL	669	275	252	99

FIGURE 4. Location and type of land treatment within the Blue Creek Watershed.


☆ Phase I* Mechanical Practices
● Phase I Cultural Practices
◓ Phase II* Cultural Practice
□ Phase II Mechanical Practice

* Phase I; 1979 - 1980
Phase II; 1981

TABLE 7

ASCS cost of conservation practice acres benefited and tons of soil saved by practice and year.

Year-Practice	ASCS Cost Share Paid	Acres Benefited	Tons Saved Per Acre	Total Soil Saved
1979				
Contouring	1568.00	224	10.0	2240
Structures	7412.00	37	7.6	281
Waterways	5353.00	29	9.9	287
Conservation Tillage Systems	1286.00	143	13.0	1859
Terraces	13724.00	114	16.8	1915
1980				
Contouring	731.00	105	19.5	2048
Structures	4850.00	10	3.0	30
Waterways	6504.00	32	5.5	176
Conservation Tillage System	1624.00	25	17.0	425
Terraces	11522.00	83	16.6	1378
Critical Area Seeding	5188.00	35	28.0	980
Vegetative Cover	456.00	12	2.0	24
1981				
Contouring	469.00	38	11.0	418
Structures	7147.00	57	18.9	1077
Waterways	4822.00	73	10.7	781
No-Till	1884.00	88	11.7	1030
Reduced Tillage	205.00	34	13.0	442
Terraces	16452.00	55	7.4	407
Vegetative Cover	1318.00	25	8.0	200

Erosion from cropland, pasture and feedlots accounts for 95% of the total watershed erosion potential. Eroded soil frequently does triple damage; first, where it originates; second, when in transit; and third, where it deposits (Meyer, 1971). As of October 1, 1981 erosion from these lands had been reduced by 26.7%. 60.0% of this reduction in erosion results from the application of cultural practices, the remainder results from the implementation of structural practices. As of October 1, 1981 70% of the adjusted goal has been achieved, erosion has been reduced by 16,495 tons.

TABLE 8

ASCS Cost share payment per ton of soil saved by practice and year.

Year	Practice	ASCS Cost of Soil Save ($/ton)
1979	Contouring	0.70
	Structures	26.38
	Waterways	18.65
	Conservation Tillage & No Till	1.23
	Terraces	9.63
1980	Contouring	0.36
	Structures	161.67
	Waterways	36.95
	Conservation Tillage & No Till	0.95
	Terraces	7.27
	Critical Area Seeding	7.00
	Vegetative Cover Improvement	25.39
1981	Contouring	0.78
	Structures	6.64
	Waterways	6.17
	No-Till	1.56
	Reduced Tillage	0.46
	Terraces	53.89
	Vegetative Cover Improvement	8.79

The information presented in Table 8 indicates among cultural practices, contouring is the most cost-effective practice for saving soil in 1979 and 1980. In 1981 reduced tillage was the most cost-effective in terms of soil saved.

Precipitation

Precipitation data for Water Year 1981 was measured at five stations (Figure 3). Daily precipitation by station is presented in Appendix 1. Table 9 summarizes the normal and total monthly precipitation for Water Years 1980 and 1981 in the watershed. The National Oceanic and Atmospheric Administration, Griggsville, Illinois Weather Reporting Station's records were utilized to determine the historic (normal) precipitation record in the Blue Creek Watershed. Figure 5 is a graph of normal precipitation measured at Griggsville, and Water Year monthly precipitation in the Blue Creek Watershed. Precipitation was 17.5% above normal during Water Year 1981. This is a 41.3% increase over Water Year 1980.

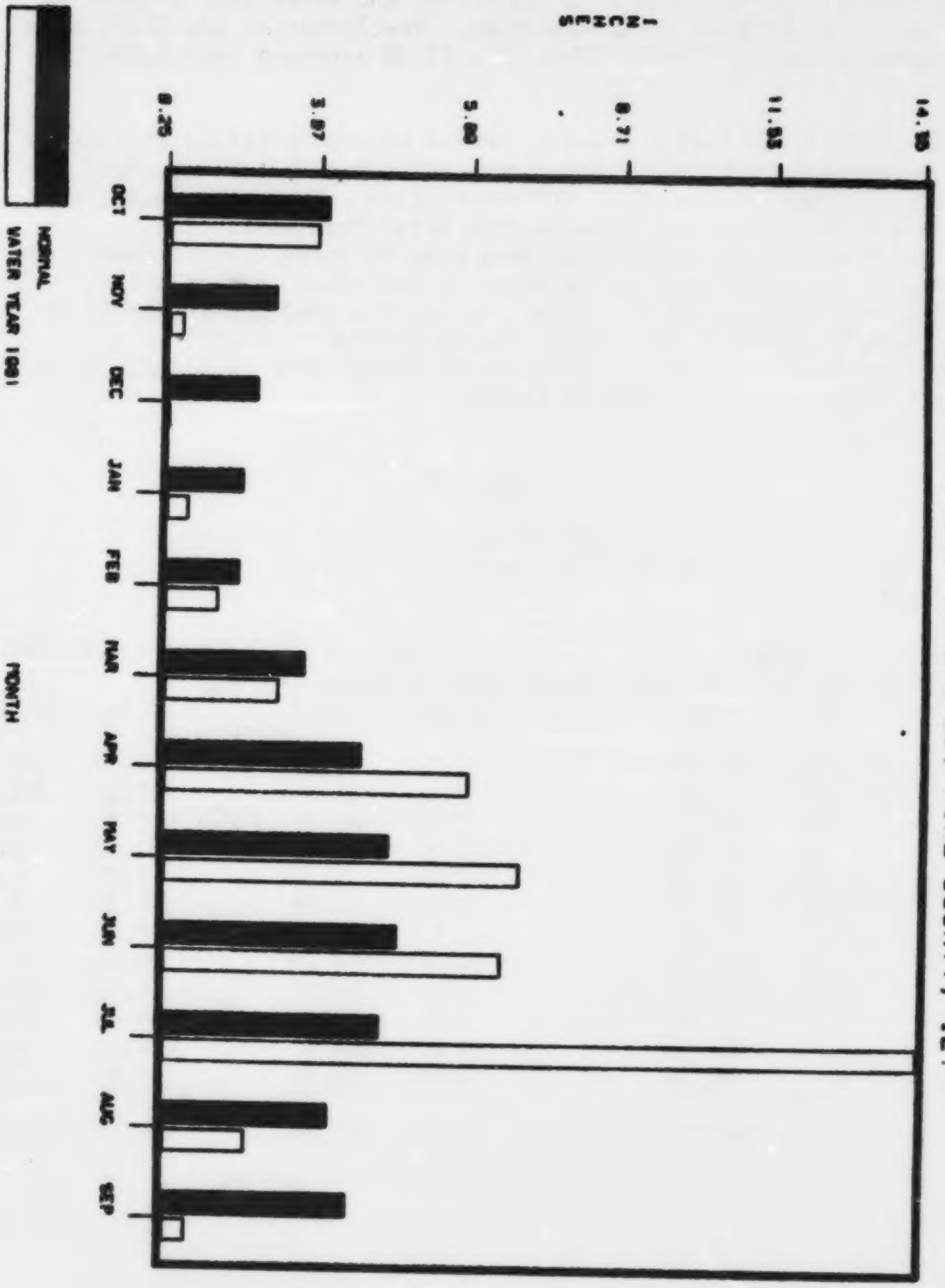
Wischmeier (1965), defined a storm as period of precipitation of 1.27 cm (0.5 in.) unbroken by 6 hours of non-measurable precipitation. This definition was used for rainfall differentiation. Table 10 summarizes the storm and non-storm precipitation for Water Year 1981. The percentage of monthly precipitation that came in storm events ranged from 0% to 85%, it averaged 50% from December to September, 50% of all measured precipitation came in storms, during the 1980 Water Year 65.6% came in storms. In Water Year 1981, the percentage of monthly precipitation that occurred as storm events ranged from 0% to 94, 79% of all measured precipitation came in storms.

TABLE 9

Water Years 1980-81 and long-term (1941-70)
monthly precipitation averages.

	NORMAL (Griggsville Station)		1979-80 (Watershed Stations Average)		1980-1981	
	(in)	(mm)	(in)	(mm)	(in)	(mm)
October	3.18	80.77	1.52	38.60	3.00	76.17
November	2.23	56.65	1.88	47.75	0.50	12.70
December	1.90	48.26	2.75	69.85	0.25	6.35
January	1.64	41.65	0.25	6.35	0.63	16.00
February	1.60	40.64	0.05	1.27	1.22	30.98
March	2.82	71.62	3.83	97.28	2.35	59.67
April	3.87	98.29	2.10	53.34	5.86	148.79
May	4.39	111.50	4.32	109.72	6.81	172.91
June	4.55	115.57	2.54	64.51	6.48	164.35
July	4.24	107.69	1.37	34.79	14.35	364.35
August	3.29	83.56	4.11	104.39	1.77	44.94
September	3.64	92.45	3.74	94.99	0.67	17.01
Annual	37.35	948.75	28.46	722.84	43.89	1114.40

FIGURE 5



MONTHLY NORMAL AND WATER YEAR 1981 PRECIPITATION AVERAGES
IN THE BLUE CREEK WATERSHED, PIKE COUNTY, IL.

TABLE 10

Monthly; storm and non-storm precipitation; Water Year 1981.
Number of observations in parenthesis.

	Storm		Non-Storm		Total
	in	%	in	%	in
October	2.39	79.7 (2)	0.61	20.3 (4)	3.00
November	-0-	-0- (0)	0.50	100.0 (3)	0.50
December	-0-	-0- (0)	0.25	100.0 (2)	0.25
January	-0-	-0- (0)	0.63	100.0 (2)	0.63
February	-0-	-0- (0)	1.22	100.0 (4)	1.22
March	2.12	90.2 (2)	0.23	9.8 (2)	2.35
April	5.48	93.5 (5)	0.38	6.5 (3)	5.86
May	5.74	84.3 (3)	1.07	15.7 (7)	6.81
June	5.34	82.3 (4)	1.14	17.7 (5)	6.48
July	13.44	93.7 (7)	0.91	6.3 (6)	14.35
August	-0-	-0- (0)	1.77	100.0 (6)	1.77
September	-0-	-0- (0)	0.67	100.0 (2)	0.67
Total	34.51		9.37		43.88

The percentage of monthly precipitation that occurred as storm events during P1-1980 was 74%, during the same period in 1981 it was 86%. P1 is the time of year when the soil is most susceptable to erosion to the lack of surface cover.

Streamflow

A summary of daily streamflow data measured at the water quality monitoring stations is presented in the Appendix Section. Tables A, B, and C show average daily, monthly maximum. Figure 6 is a flow duration curves for Station C.

Precipitation and Runoff

Runoff is a summary term used to refer to the various processes which ultimately produce streamflow. The word "runoff" by itself does not convey any idea of the source or timing of the water yielded by a basin. Total precipitation, antecedent precipitation, soil moisture, ground cover and storm characteristics influence the quantity of streamflow produced by any given event.

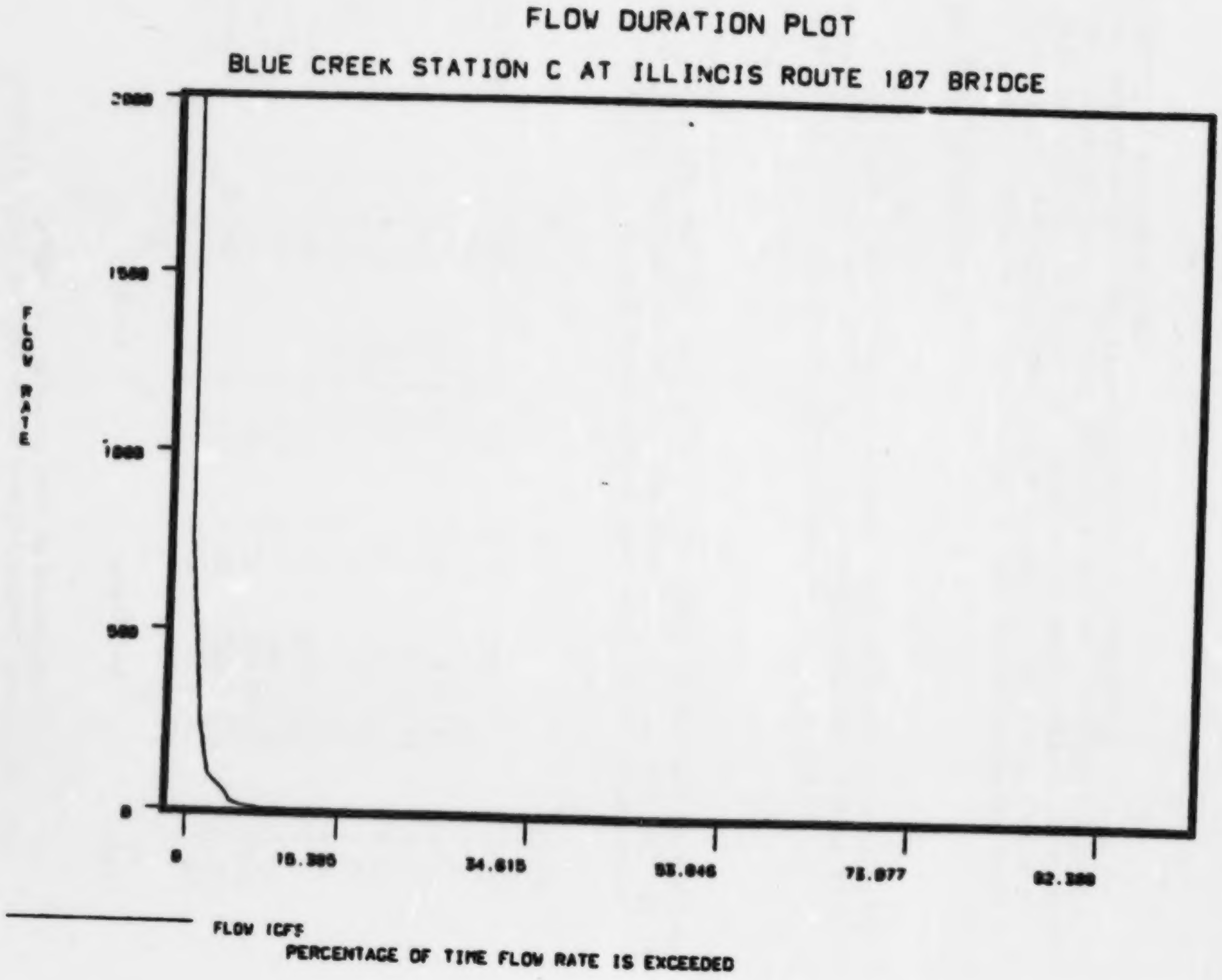

FLOW DURATION PLOT
BLUE CREEK STATION C AT ILLINCIS ROUTE 107 BRIDGE
FLOW RATE
2000
1500
1000
500
0
0
15.385
34.615
53.846
73.077
92.308
FLOW (CFS)
PERCENTAGE OF TIME FLOW RATE IS EXCEEDED

FIGURE 6

The rainfall-runoff ratio ranged from 1.5% in July to 64.5% in February and averaged 8.0% for the ten month period recorded during Water Year 1980. Precipitation was 46% below normal during this time period. During Water Year 1981, the rainfall-runoff ratio ranged from 6.0% in November to 80.1% in July and averaged 41.9% for the Water Year (Table 11). Precipitation was .7% above normal during Water Year 1981.

TABLE 11

Rainfall, runoff and runoff ratio during
Water Year 1981, at Station C.

Month	Rain (in)	Runoff (in)	Runoff ratio (%)
October	3.00	0.29	10.0
November	0.50	0.03	6.0
December	0.25	0.16	64.0
January	0.63	0.03	4.8
February	1.22	0.18	14.8
March	2.35	0.11	4.7
April	5.86	1.02	17.4
May	6.81	2.34	34.4
June	6.48	2.33	36.0
July	14.35	11.50	80.1
August	1.77	0.23	13.0
September	0.67	0.14	20.9
Totals	43.34	18.36	41.9

The high 1981 runoff ratio in comparison to 1980 Water Year's ratio is indicative to the above normal precipitation during Water Year 1981 as well the timing of the rainfall. Above normal precipitation in May and June allowed the soil to become saturated, thus the 300% increase over normal precipitation occurred in July most of it resulted in runoff.

Storm Events and Runoff

Wischmeier (1965) definition of a storm described earlier is used for this analysis. Runoff produced directly by storm precipitation is considered storm runoff.

The source area of runoff in a watershed expands and contracts according to rainfall rates and capacity of the soil to retain and release water (Dunne, 1978). The variable source area concept explains how a channel network grows to many times its average perennial dimensions during storm runoff as streams become both longer and wider. The variable source concepts applies to the Blue Creek Watershed because infiltration is not a limiting factor (Dunne, 1978). The variable source area concept is important when attempting to ascertain streamflow constituent transport.

The quantity of runoff from a storm depends on (1) the moisture conditions of the watershed at the onset of the storm and (2) the storm characteristics rainfall amount, intensity, and duration.

Table 12 is a summary of all storms (Wischmeier definition) measured in the Blue Creek Watershed during Water Year 1981. Total event precipitation is the total precipitation measured at Rain Gauge 1.

The largest storm event measured was on July 7, 1981 total event precipitation was 4.34 in. (11.02 cm), it produced a peak discharge of 2109.2 cfs (59.69 cum/s). The smallest storms were measured on May 22, and June 19, 1981, total event precipitation was 0.52 in. (1.37 cm) and it produced a peak discharge 16.7 cfs (0.47 cu.m/s). The smallest peak discharge, 1 cfs (0.03 cm.m/s), was measured on August 4, it resulted from a total rainfall of 0.68 in. (1.73 cm) this followed a lengthy dry period. The largest peak discharge, 2109.2 cfs (59.69 cu.m/s), resulted from 4.34 in (11.02 cm) of rainfall on July 4.

TABLE 12

Summary of all storms measured in the Blue Creek Watershed during Water Year 1981.

Date	Total Event Precipitation (in)	(cm)	Rank	Peak Discharge (cfs)	(cu.m/s)	Rank
10-17-80	1.71	4.34	10	3.4	0.09	19
10-27-80	0.68	1.73	20	0.3	0.01	21
03-05-81	1.09	2.77	14	24.9	0.69	15
03-24-81	1.03	2.62	17	0.3	0.01	21
04-11-81	2.17	5.51	4	149.0	4.17	12
04-12-81	0.83	2.11	18	95.9	2.69	13
04-13-81	1.17	2.97	12	383.1	10.73	9
04-19-81	0.78	2.01	19	10.6	0.30	18
04-22-81	0.52	1.32	21	16.7	0.47	17
05-10-81	1.99	5.05	5	74.8	2.09	14
05-17-81	1.05	2.67	16	23.5	0.66	16
05-18-81	2.70	6.86	2	1235.5	34.59	5
06-15-81	1.08	2.74	15	232.2	6.50	10
06-19-81	0.52	1.32	21	0.5	0.01	20
06-21-81	1.80	4.57	8	638.7	17.88	8
06-24-81	1.94	4.83	6	1384.5	38.77	4
07-04-81	4.34	11.02	1	2109.2	59.06	1
07-19-81	2.63	6.68	3	658.3	18.43	7
07-23-81	1.11	2.82	13	166.6	4.66	11
07-25-81	1.78	4.52	9	1581.6	44.28	2
07-26-81	1.93	4.90	7	1480.6	41.46	3
07-27-81	1.65	4.14	11	1153.7	32.30	6

Suspended Matter

Total suspended solids (TSS) in the water column are composed of volatile and non-volatile fractions. Volatile suspended solids (TVS) are organic in nature, while non-volatile solids (NVS) are generally inorganic. Suspended matter impacts freshwater ecosystems biochemically, chemically, physically, and biologically (Davenport, 1982B). Soil erosion is primary requisite for sediment production (Knox, 1977).

The Illinois Pollution Control Board (IPCB) has not specified general use or public/food processing water supply standards for suspended solids. However, Rule 203(a) of Chapter 3 requires that waters not have unnatural sludge or bottom deposits, floating debris, visible oil, odor, unnatural plant or algal growth, unnatural color or turbidity, or matter in concentration or combinations toxic or harmful to human, animal, plant or aquatic life of other than natural origin.

Concentrations of TSS were determined for each sample and averaged by Water Year, analysis period and station. These data are summarized in Table 13. Comparisons of means and standard deviations for TSS shows the extreme variations in Water Years, stations and analysis periods.

Mean TSS concentrations decreased from measurements period P1 to P3 at all stations. This decrease is related to the interaction of surface cover management and precipitation patterns on the watershed about one-third of the average precipitation occurs during P1, but the erosivity of the rainfall during this period is often high due to the intense nature of thunderstorms. Also, there is little or no soil cover during this perid.

TABLE 13

Mean, standard deviations and number of TSS samples for all gauging stations by Water Year and analysis periods in milligrams per liter.

	A	B	C
Water Year 1980 ($\bar{X}$)	13.2	142.0	2892.6
standard deviation	19.8	370.8	7551.6
sample size	68	154	248
Water Year 1981 ($\bar{X}$)	28.2	200.6	1961.8
standard deviation	50.1	974.7	4964.1
sample size	108	261	315
P1 -- 1980 ($\bar{X}$)	17.7	217.6	484.36
standard deviation	28.2	566.1	11745.0
sample size	32	62	93
P1 -- 1981 ($\bar{X}$)	35.9	379.7	3863.6
standard deviation	61.6	1584.0	6853.7
sample size	72	93	134
P2 -- 1980 ($\bar{X}$)	10.0	71.8	1317.1
standard deviation	4.7	85.7	2153.0
sample size	45	141	203
P2 -- 1981 ($\bar{X}$)	26.7	175.0	1184.7
standard deviation	40.0	611.5	2900.7
sample size	85	112	126
P3 -- 1980 ($\bar{X}$)	10.0	80.9	450.1
standard deviation	4.3	148.2	947.0
sample size	31	43	52

Mean 1981 Water Year TSS concentrations by station ranged from 1961.8 mg/l at Station C to 18.2 mg/l at Station A. Mean 1981 Water Year TSS concentrations decreases from Station C to Station A. The difference between mean TSS concentrations at Stations C and B results from the effects that the flow constricting structure at Station B has on streamflow. Maximum and minimum TSS concentrations varied by station by period (Table 14). The high minimum values at Station B during P1 and P2 result from the slowing down and concentrating of streamflow under the bridge. As streamflow is slowed, the solids settle out in pools or in the flood plain. The decrease in mean TSS concentration between the lake inflow (Station B) and lake outflow (Station A) results from dilution, sedimentation, and decomposition of particulate matter. This is often referred to as the lake trapping efficiency, it is expressed as a percent reduction. Bogner, (1979) calculated the trap efficiency of the lake to be 93%, 1980 and 81 data indicate the trapping efficiency to be 98%.

TABLE 14

Maximum and minimum TSS and TVS concentrations by station by analysis period in milligrams per liter.

	A		B		C	
	TSS	TVS	TSS	TVS	TSS	TVS
P3-1980						
Max	24.0	7.0	970.0	130.0	3600.0	230.0
Min	2.0	0.0	10.0	2.0	3.0	0.0
P1-1981						
Max	444.0	98.0	15000.0	1040.0	47200.0	1840.0
Min	4.0	1.0	34.0	4.0	7.0	2.0
P2-1981						
Max	240.0	22.0	4720.0	383.0	15200.0	747.0
Min	3.0	0.0	21.0	3.0	7.0	1.0

Mean TSS concentrations varied by Water Year at each station, with 1980 concentrations highest. Even though rainfall was higher during Water Year 1981 than 1980, this could result from the land treatment activities that occurred on the watershed during 1980 and 81.

The effects of suspended solids on fish has been reviewed by the European Inland Fisheries Advisory Commission (1965). This review identified four means by which suspended solids adversely affect fish and fish food populations:

1. By acting directly on the fish swimming in water in which solids are suspended, and either killing them or reducing their growth rate, resistance to disease, etc.;

2. By preventing the successful development of fish eggs and larvae;

3. By modifying natural movements and migrations of fish;

4. By reducing the abundance of food available to the fish (USEPA, 1976).

The NAS-NAE suspended solids criteria (NAS-NAE, 1972) would indicate that at Station A the fisheries potential would be good to moderate, the water at Station B would unlikely support good freshwater fisheries and only poor fisheries would be found at Station C during Water Year 1981. Station A's classification slipped from excellent during 1980 to good/moderate during 1981 could result from the increased precipitation and accompanying climatic factors (i.e., high winds) causing resuspension of bottom material in the profundal zones of the lake. In terms of freshwater fishers, P1 is the most environmentally sensitive period due to their normal reproduction cycle (TSS that settles out has the potential for smothering spawning beds). Also, TSS has the potential to cause respiratory interference and habitat destruction when in high concentrations. Freshwater fishers can survive high concentrations of TSS for short periods of time, excessive TSS concentrations over long periods of time would be detrimental to the aquatic population.

Concentrations of TVS were determined by Water Year, analysis period and station. These data are summarized in Table 15. Comparisons of means and standard deviations for TVS shows the extreme variations in stations and analysis periods. Mean TVS concentrations exhibited a similar trend to mean TSS's concentrations.

TABLE 15

Mean standard deviations, and number of TVS samples for all gauging stations by Water Year and analysis periods in milligrams per liter.

	A	B	C
Water Year 1980 ($\bar{X}$)	3.5	18.0	193.3
standard deviation	3.2	48.9	651.2
sample size	68	154	248
Water Year 1981 ($\bar{X}$)	5.3	21.6	116.6
standard deviation	8.2	69.4	255.6
sample size	168	261	315
P1 -- 1980 ($\bar{X}$)	4.78	26.6	242.4
standard deviation	3.95	74.7	481.4
sample size	32	62	93
P1 -- 1981 ($\bar{X}$)	6.9	36.5	230.3
standard deviation	11.7	111.2	347.7
sample size	72	93	134
P2 -- 1980 ($\bar{X}$)	2.51	9.9	125.7
standard deviation	1.78	11.9	644.9
sample size	45	141	203
P2 -- 1981 ($\bar{X}$)	4.9	19.4	63.1
standard deviation	3.1	42.0	139.9
sample size	85	112	126
P3 -- 1980 ($\bar{X}$)	2.5	10.7	38.8
standard deviation	1.4	19.4	74.2
sample size	31	43	52

TABLE 16

Mean TVS percentage of TSS concentration for all stations by Water Year and analysis period.

	Stations		
	A	B	C
Water Year 1980	26.5	12.7	6.7
Water Year 1981	19.9	10.8	5.9
P1 -- 1980	27.0	12.2	5.0
P1 -- 1981	19.2	9.6	5.9
P2 -- 1980	25.1	13.8	9.5
P2 -- 1981	18.4	11.1	5.3
P3 -- 1980	25.0	13.2	8.6

The mean TVS percentage of TSS ranged from 5.3% during P2 at Station C to 25.0% at Station A during P3 (Table 16). There was a definite "upstream-downstream" relationship with Station A having the highest value (19.9%). Mean TVS percentage of TSS increased between P1 and P2 then decreased between P3 at Stations B and C. At Station A, mean TVS percentage of TSS decreases from P1.

Turbidity

The measurement of turbidity is an attempt to quantify degree of opaqueness of water due to light scattering and absorption resulting from suspended particulate matter, dissolved organic matter, and color. Turbidity is not a uniform parameter since the quantity and quality of suspended particulate matter is so variable in nature (Reid 1961). Clay, silt, particulate organic and inorganic matter, plankton and other microorganisms may all contribute substantially to the quantity and proportions of particulate matter available. The obstruction or absorption of light energy due to turbidity exerts both beneficial and detrimental effects. Turbidity can, for example, effectively reduce the vertical extent of the euphotic zone, thus limiting photosynthetic production of oxygen and as a result restrict usable biological habitat. It can also make surface waters more habitable for light-sensitive forms and increase water temperature by radiation from suspended matter.

The nature of materials causing turbidity is important. Pesticides absorbed on suspended inorganic matter for example, may be removed from the water column and carried to the bottom, while suspended organic matter, living and dead, serves as an important food source. (Sefton, 1980).

Historically, the most accepted procedure for determining turbidity was based on the Jackson turbidimeter which made use of light penetration through a vertical column of water. Presently, turbidity is measured in Nephelometric turbidity units (NTU's), because JTU's are not practical below 25 units due to limits of the measuring device (USEPA, 1976). The USEPA (1976) criteria for turbidity is that "settleable and suspended solids should not reduce the depth of the compensation point for photosynthetic activity by more than 10 percent from the seasonally established norm for aquatic life." There is no universal agreement as to levels of turbidity to be allowed. Stall (1972) indicated that the rivers of Illinois tend to maintain a residual turbidity during most of the year.

TABLE 16

Mean and standard deviation of turbidity values by station, Water Year and analysis period expressed in NTU's

	Stations		
	A	B	C
Water Year 81 ($\bar{X}$)	20.7	62.1	32.5
standard deviation	17.3	65.6	46.7
P3 1980 ($\bar{X}$)	6.3	26.9	6.4
standard deviation	0.8	8.14	1.9
P1 1981 ($\bar{X}$)	21.5	83.0	48.3
standard deviation	16.5	86.4	57.5
P2 1981 ($\bar{X}$)	18.1	42.3	24.1
standard deviation	15.9	32.1	39.2

Comparisons of means with standard deviations of turbidity values shows the extreme variations in stations and analysis periods (Table 17). Turbidity increases between Stations C and B, the increase in Station B values result from the decrease in flow. Turbidity decreases from lake inflow (Station B) to lake outflow (Station A).

Turbidity varied between analysis periods with P1 having the highest values and P3 the lowest. This corresponds to Stall's (1972) findings that in Illinois the highest turbidities will occur during May and June. This results from there being little or no soil cover due to planting activities during the months of May and June, also severe thunderstorms can be expected. The low turbidity during P2 corresponds to the period when the agricultural crop canopy cover was nearly 100%. During periods of low flow, organic matter in stream water accounts for much turbidity (Costa, 1977). Precipitation during P3 was minor and occurred as snowfall on frozen ground.

Nutrients

Sediment and water components of runoff may degrade the quality of surface waters with nutrients that could have been utilized by growing plants. These nutrients not only contribute to water quality deterioration, but also represent an economic loss of fertility for the farmer (Burwell, 1975).

Two problems are associated with nutrients in the aquatic environment: the water may be toxic to humans, animals, or fish when the concentration of certain nutrient forms exceeds a critical level; and euthrophication may be accelerated. Nitrogen, phosphorus, and potassium are essential nutrients for plant growth. Free floating aquatic vegetation, such as phytoplanton, depends on dissolved nitrogen and phosphorus compounds for its nutrient supply. Growth of these aquatic and phosphorus compounds for the availability of other nutrients. Dense algal growths sometimes occur in water resources that periodically receive increased concentrations of nutrients. These algal growths are generally undesirable and impair the use of the resource by people. The major sources of nutrients in streamflow are geochemical weathering, fertilizer and direct deposition from atmospheric sources. Nutrients from fertilizer can come from runoff of agricultural land or from groundwater return flow draining agricultural land. Nutrients also come from runoff and leachate from animal waste in livestock operations or from the animal waste disposal systems.

Phosphorus (P)

Phosphorus (P) is a key metabolic nutrient and the supply of this element often regulations the productivity of natural waters. In natural systems, P occurs as the orthophosphate anion (PO3-) which may exist purely in organic forms H_2PO_2 - and HPO4-) or be incorporated into an organic species (organic P). Under certain circumstances inorganic orthophosphate may exist as a poly or condensed phosphate. A secondary distinction is made between particulate and dissolved (DSP) forms of P, the split conventionally being made at 0.45 um. Particulate matter is easily removed by filtration in the field with filtered samples analyzed for dissolved phosphorus (Ryden, et al, 1973).

P in its many forms in stream water originates from biological processes, geophysical erosion, commercial fertilizers, animal wastes, leachate and geochemical weathering of bedrock. Geophysical erosion is the process of physical breakdown of bedrock and smaller particles. Geochemical weathering dissolves and transports constituents to the streams. Rates are controlled by characteristics of climate, soils, topography, biotic agents and bedrock formations (Fredricksen, 1979). PTL from commercial fertilizers and animal waste enters the stream ecosystem from leaching and percolation thru the soil matrix.

Total Phosphorus (PTL)

The Illinois Pollution Control Board (1977) has established a general use standard of 0.05 mg/l for PTL, in any lake or stream at the point where it enters a lake. A general index of maximum desirable concentrations is as follows; 0.10 mg/l in flowing waters, 0.05 mg/l for streams flowing into lakes and reservoirs, and 0.025 mg/l in lakes and reservoirs (U.S. Environmental Protection Agency, 1976).

The overall, short-term impact of surface runoff derived P on standing waters is expected to be high because a large proportion of the average annual discharge of PTL occurs over only short periods of time during the annual cycle. Furthermore, the impact of the PTL load carried in streams is expected to be greater during late spring and early summer when aquatic microorganisms are in the potentially active growth phase (Ryden, et al, 1973).

The mean concentrations of PTL by station, Water Year, and the individual measurement periods are shown in Table 18. The individual observations are listed in the data section of the Appendix Section.

Mean 1980 and 1981 Water Year PTL concentrations at Station C exceeded the USEPA recommended maximum desirable concentration of 0.1 mg/l for flowing water. Mean 1980 and 1981 Water Year PTL concentrations at Station B exceeded the USEPA recommended maximum desirable concentration of 0.05 mg/l for streams flowing into lakes and the Illinois general use standard. Mean 1981 Water Year PTL concentration at Station A exceeded the USEPA recommended value.

In general, there was a significant difference between mean Water Year PTL concentrations at all three stations. This difference results from the 41.3% increase in precipitation from Water Year 1980 to 1981 and the increase in conservation tillage could have had an impact. Conservation tillage reduce sediment P and thus reducing PTL, but at the same time DSP losses increase. Basis and other (1978), have shown that DSP losses increased from various conservation tillage system, especially no-till, compared to the conventional system. They attributed the higher losses from conservation tillage systems to a lack of incorporation of broadcast P fertilizers, they also suggested that leaching of plant residue may be an additional source. Other researchers, reported no greater losses of DSP from conservation tillage.

The mean concentrations of PTL decreased significantly between the measurement periods P1 and P2 during 1980 at Stations A and B. PTL decreased 86% during P1 and 75% during P2. PTL measured at Station B decreased 31% between P1 and P2. The elevated concentrations of PTL at Station B during P1, could result from the fertilization activities being carried out in the watershed, high streamflow during spring may scour algae from rocks in the stream thus minimizing consumption and release PTL from bottom sediment.

Mean concentrations of PTL increased significantly at Station B and Station C from P2 to P3 during 1980. Table 18 shows at Station C, mean PTL concentrations increased over 600% from P2 to P3. The mean PTL baseflow concentration during P3 was 0.08 mg/l and the mean PTL storm event concentration during this period was 3.41 mg/l. The mean PTL P3 concentration is a weighed average based on 10 storm event samples and 4 baseflow samples. In runoff from tilled land, PTL is predominantly associated with non-volatile suspended solids (Mueller, 1981). Since these runoff samples did not contain large amounts of organic matter, (less than 10%), P associated with non-volatile suspended solids probably makes up a large percentage of PTL; thus its impact upon water quality is reduced since it is unavailable for plant uptake and consequently has no immediate impact on algal growth. Station B's concentration reflect the streamflow at Station C during this period.

The mean concentrations of PTL decreased significantly between P1 and P2 at Station A during 1981. Mean PTL, measured at Station C decreased 45% between P1 and P2. This could result from interrelationship from the fertilization activities being carried out in the watershed during P1 and the rainfall pattern. High streamflow during spring may scour algae from rocks in the stream, thus minimizing consumption and the release of PTL from bottom material. The amount of PTL available for transport during P2 is reduced due to plant utilization.

TABLE 18

Mean, maximum, minimum and standard deviations of PTL concentrations for all stations by Water Year and analysis period in milligrams per liter.

		Station	
	A	B	C
1980 Water Year $(\bar{X})$*	0.06	0.23	0.43
standard deviation	0.02	0.08	0.47
sample size	20	20	19
1981 Water Year $(\bar{X})$	0.12	0.77	2.74
standard deviation	0.08	1.48	2.34
sample size	56	51	102
P1 -- 1980 $(\bar{X})$	0.08	0.29	0.21
standard deviation	0.03	0.09	0.10
sample size	7	7	6
max	0.12	0.41	0.42
min	0.05	0.15	0.12
P1 -- 1981 $(\bar{X})$	0.13	0.74	3.61
standard deviation	0.08	1.34	2.38
sample size	27	17	60
max	0.42	5.80	8.70
min	0.06	0.13	0.14
P2 -- 1980 $(\bar{X})$	0.05	0.18	0.39
standard deviation	0.01	0.06	0.46
sample size	21	21	21
max	0.08	0.32	2.10
min	0.03	0.11	0.12
P2 -- 1981 $(\bar{X})$	0.13	0.54	1.97
standard deviation	0.08	1.07	1.94
sample size	23	24	37
max	0.33	5.30	6.10
min	0.06	0.07	0.14
P3 -- 1980 $(\bar{X})$	0.05	0.42	2.46
standard deviation	0.00	0.61	1.84
sample size	5	5	14
max	0.06	1.50	4.90
min	0.05	0.10	0.07

*May-September

There is a distinct "upstream-downstream" trend in mean PTL concentrations during all periods of analysis (Table 18). Station C had the highest values and Station A the lowest (Figure 2). Decreases in PTL concentrations from the upstream Stations C and B to the lake outflow Station (A) is due to a number of factors: 1) dilution, 2) biological uptake and 3) absorption and/or adsorption by chemically active material. Adsorptions of P on clay minerals involve at least two mechanisms -- Vander Wal forces of attraction and isomorphic substitution of P for silicate in the clay structure. Phosphate anions are removed from water by kaolinite and montmorillanite (Van Olphen, 1963). P, bounded tightly to soil particles, is removed from suspension as sediment (Lin, 1972). Sediment may act as reservoirs of PTL in natural systems and can be released during periods of disturbance (Stumm, 1970). Adsorption or reaction of PTL with bases and metals (Henn, 1975) is the major reason for reduced concentrations in the soil solution (groundwater) and streams. Rapid utilization of PTL in the form of PO_4-P, by aquatic vegetation also occurs in flowing streams and lakes (Wetzel, 1975). There is a change in land use/cover composition between Stations B and C. The management pattern in this area (refer Figure 2) is distinctly more conservation oriented and less intense agricultural production than that area draining to Station C. Figure 5 shows that the majority of the conservation applied in the watershed, have been between Stations B and C. This change in management pattern can be associated with less PTL available for input into the aquatic system. The combination of these phenomenons cause this decrease.

The decreases in PTL concentrations between the lake inflow and outflow stations result from dilution, biological uptake and fixation by sediment. PTL concentration measured at lake site 2 is lower than that measured at Station B, whereas lake site 1 values are equivalent to those at Station A. However, Ryden (1973), asserts a major unknown factor centers around the effects of mixing as streams enter standing waters. He suggests that temperature density and turbulence differences between stream water and standing water will have some effect on the degree of mixing. The degree of mixing influences the degree that dilution, biological uptake and fixation by sediment impact upon PTL concentration in the water column.

Dissolved Phosphorus (DSP)

In terms of water quality PTL data are not accurate indicators because this measure does not determine the portion of P available for aquatic plant growth. A better assessment of pollution potential is an estimate of DSP which is readily available for plant uptake and consequently, has an immediate impact on algal growth (Mueller, 1981).

There is no general use standard for DSP. Table 19 shows the means and standard deviations of DSP by Water Year, analysis period and station.

TABLE 19

Mean and standard deviations of DSP concentrations
for all stations by Water Year and analysis period
in milligrams per liter.

		Station	
	A	B	C
1981 Water Year $(\bar{X})$	0.76	0.37	0.10
standard deviation	-	-	-
sample size	3	3	1
P1 -- 1981 $(\bar{X})$	0.11	0.55	-
standard deviation	0.03	0.40	-
sample size	2	2	-
P2 -- 1981 $(\bar{X})$	0.01	0.06	0.18
standard deviation	0.01	0.08	0.14
sample size	7	7	7

Nitrogen (N)

Most of the nitrogen (N) in a stream has a terrestrial origin. Major sources of N are atmospheric deposition, biological fixation, fertilizers, and leachate from animal wastes. The forms of N in water include dissolved molecular N proteins and amino (acids), ammonia (NH3), nitrate (NO3), and nitrite (NO2). Loss of N to streams seems to be regulated primarily by biological processes (Likens, 1977) and geochemical reactions in parent material and bedrock (Fredriksen, 1979). Stored N in the soil is utilized by vegetation and returned partly to the soil as litter fall when plants die. Organic N is unavailable forms (NH_4-N, NO_3-N) by biological activity.

Sediment can be a source of N to the aquatic environment. Suspended solids in streamflow may have adsorbed or complexed with forms of N either organic or inorganic compounds. Clay minerals and amorphous material, fine grain sediments, have chemically active surfaces which adsorb N compounds (Loughnan, 1969). Legumes, can fix large amounts of N in the soil which can subsequently leach into surrounding waters.

Concentrations of water-soluble N in surface runoff usually were highest at the beginning of the cropping season and declined progressively during the remainder of the year. This seasonal effect was attributed to progressive N removal by crop use, leaching losses, and N in the equilibration process with organic matter (Burwell, 1977; Schuman, 1973). This seasonal effect is important for designing conservation practices to control N losses during critical runoff erosion periods.

TABLE 20

Mean, maximum, minimum and standard deviations of TKN concentrations for all stations by Water Year and analysis period in milligrams per liter.

		Station	
	A	B	C
1980 Water Year ($\overline{X}$)*	0.91	1.36	1.74
standard deviation	0.31	0.54	1.25
sample size	21	21	20
1981 Water Year ($\overline{X}$)	0.98	2.13	12.20
standard deviation	2.60	2.85	20.70
sample size	66	48	102
P1 -- 1980 ($\overline{X}$)	1.15	1.71	1.13
standard deviation	0.33	0.66	0.51
sample size	8	8	7
max	1.5	2.5	2.0
min	0.5	0.7	0.6
P1 -- 1981 ($\overline{X}$)	1.06	3.06	16.70
standard deviation	0.22	4.22	25.57
sample size	29	19	60
max	1.6	20.0	191.0
min	0.7	0.4	0.7
P2 -- 1980 ($\overline{X}$)	0.76	1.11	1.62
standard deviation	0.14	0.30	1.27
sample size	21	21	21
max	1.1	1.6	5.3
min	0.6	0.6	0.5
P2 -- 1981 ($\overline{X}$)	0.97	2.34	6.98
standard deviation	0.19	3.65	6.88
sample size	23	24	37
max	1.2	19.0	23.0
min	0.5	0.9	0.6
P3 -- 1980 ($\overline{X}$)	0.86	1.80	9.29
standard deviation	0.11	2.02	6.80
sample size	5	5	14
max	1.0	5.4	18.0
min	0.7	0.6	0.5

*May-September

Total Kjeldahl Nitrogen (TKN)

Analysis for total Kjeldahl nitrogen (TKN) measures both ammonia and organic nitrogen. TKN minus ammonia nitrogen is equivalent to the organic N level. Both of these forms occur in organic detritus resulting from natural biological activity. Since ammonia and organic N are both possible contributors to the nutrients pool, their quantification is important in assessing the amount of nitrogen available for biological activities (Sefton, 1980).

Concentrations of TKN were determined for each weekly streamflow sample and averaged by Water Year, period of anaysis and station. These data are summarized in Table 20. Comparisons of means with standard deviations for TKN shows the extreme variations in stations and periods of analysis.

Mean 1981 Water Year TKN concentrations by station ranged from 12.2 mg/l at Station C to 1.86 mg/l at Station A. Laterally, mean 1981 Water Year TKN decreases from Station C to Station A. Station A's TKN concentration is higher than lake site 1 (Table 20), this increase results from organic matter contribution from the land area surrounding Station A. Mean 1980 Water Year TKN concentration exhibited the same trends as the 1981 data. The significant increases between 1980 and 1981 Water Year concentrations at Station A and C probably result from the increase in rainfall between the Water Years. The differences at Station B are not significant to the large variability in concentrations. The evaluated mean TKN concentrations at Station C results from contribution of storm events and that it is a weighed mean.

Organic Nitrogen

Organic nitrogen (N) is unavailable for immediate plant use, it is mineralized to more available forms (NH_3-N, NO_3-N) by biological activity. Organic N is primarily formed and degraded by biological action. Common species of organic nitrogen are proteins, protein derivatives, perines, pryimidines, and urea. Some of these are readily degradable and some are not. Farm runoff is a source of organic N (Willrich et al., 1970).

Mean Water Year values indicate an "upstream-downstream" trend, with Station C having the highest value. Organic N decrease thru the lake and then increases at Station A. This increase at Station A results from littoral zone contribution. The decrease in mean organic N between P1 and P2 results from lack of organic matter contributions due to low rainfall, transformations of organic N to more useable forms, and by the permanent loss of organic N to sediments (Wetzel 1975), which serve as a source of N as well as a sink (Austin, 1973).

During Water Year 1981 mean TKN measured at Station C averaged 79% organic N, the lowest percentage of all sampling stations. The organic N percentage of TKN at Station B was 90% and at Station A 83% (Table 21). The difference between Water Year results from the 41.3% increase in rainfall. Land treatment activities would impact organic N concentrations, due to increase amount of residue available for transport.

TABLE 21

Average percentage of TKN, as Organic N by Water Year, analysis period and station.

	Station		
	A	B	C
1980 Water Year	95.6	86.8	78.7
1981 Water Year	82.7	90.1	98.4
P1 -- 1980	96.5	83.0	83.2
P1 -- 1981	95.3	91.8	98.7
P2 -- 1980	90.2	91.9	79.0
P2 -- 1981	87.6	94.4	97.7
P3 -- 1980	*	78.9	97.0

*NH3 not measured

Nitrates-Nitrites (N32)

Fertilizers, biological fixation, mineralizations and nitrofication input nitrate (NO3-N) into the aquatic system. Denitrification, plant uptake, immobilization by soil organic matter and leaching are processes by which NO3-N leaves the system. NO3-N lost from the terrestrial system through soil leaching is the dominant source observed in stream water.

Specific agricultural activities associated with NO3-N are disposal of animal waste and fertilization. Anhydrous ammonia and urea are the principal forms of commercial fertilizer applied presently. Animal manure is a principal form of fertilizer within this watershed due to large livestock operations. All three of these fertilizers are a source of nitrate, because the breakdown of anhydrous ammonia, urea, and animal manure to NO3-N.

Concentrations of (N32) were determined for each weekly streamflow sample and averaged by Water Year, period of analysis and by station. These data are summarized in Table 22. Comparisons of means with standard deviations of N32 shows the extreme variations in stations and periods of analysis.

There was significant decrease between N32 concentrations during P1 and P2 at Station B and C during Water Year 1980. At all three stations during Water Year 1981, there was a significant decrease between N32 concentrations during P1 and P2. Available N32 increases during P1 (Spring) due to mineralization of organic N and inputs from fertilizer. This N32 is free to move with the soil water. This flow enters the stream course by percolation (subsurface flow). Consumption by crops during P2 (summer) reduces available N32 for soil water transport, thus reducing the concentration in streamflow. N32 concentrations in soil are nearly exhausted about the time of corn senescence (Langdale, 1978). There is a significant increase in N32 concentrations from P2 to P3 at all stations. This results from N32 contributed from precipitation, manure spreading, mineralization of soil organic matter, and leaching of corn residue. Amount of residue left increased from Water Year 1980 to 1981 due to the acceptance and implementation of conservation tillage systems (Table 9). There was no significant difference between N32 concentrations during P1 and P2 at Station A. Samples collected at this station reflects Pittsfield City Lake outflow and the littoral zone of the lake. There is a definite "upstream-downstream" trend in mean N32 concentrations. Station C has the highest value and Station A the lowest. This trend was exhibited during both Water Years 1980 and 1981. There is a significant difference between N32 concentrations at Stations B and A. The decrease in mean N32 concentration between the lake inflow and outflow stations results from dilutation, and biological uptake. NO3 is assimilated by algae and larger hydrophytes and reduced to ammonia. The assimilation of NO3-N and its reduction by green plants is of major proportions in the trophorgenic zone of lakes. Decreases in mean concentration between Stations C and B result from plant consumption and dilution. Mean N32 concentrations during Water Years 1980 and 1981 did not exceed the limits determined by Knepp (1973) and McCoy (1972) for adversely affecting warmwater fish. These limits are: NO3-N, 90 ppm or less and NO2-N is 5 ppm or less.

TABLE 22

Mean, maximum, minimum and standard deviations of N32 concentrations for all stations by Water Year and analysis period in milligrams per liter.

	Station		
	A	B	C
1980 Water Year $(\bar{X})$*	0.02	0.32	1.85
standard deviations	0.06	0.49	1.41
sample size	17	17	20
1981 Water Year $(\bar{X})$	0.33	0.98	2.54
standard deviations	0.30	1.29	1.99
sample size	39	35	37
P1 -- 1980 $(\bar{X})$	0.10	0.65	3.41
standard deviations	0.35	0.56	0.80
sample size	8	8	7
max	0.10	1.60	4.30
min	0.00	0.00	2.40
P1 -- 1981 $(\bar{X})$	0.24	2.19	4.01
standard deviations	0.14	1.61	2.02
sample size	12	11	13
max	0.50	5.80	6.00
min	0.10	0.13	1.10
P2 -- 1980 $(\bar{X})$	0.25	0.12	0.71
standard deviations	0.34	0.15	0.73
sample size	17	17	21
max	1.30	0.60	2.40
min	0.00	0.00	0.0
P2 -- 1981 $(\bar{X})$	0.12	0.23	2.52
standard deviations	0.11	0.21	1.29
sample size	18	18	18
max	0.40	5.30	4.8
min	0.00	0.01	0.0
P3 -- 1980 $(\bar{X})$	0.30	1.20	1.96
standard deviations	0.07	0.80	0.77
sample size	5	5	5
max	0.40	1.50	3.20
min	0.20	0.10	0.10

*May-September

Ammonia (NH3)

Ammonia is the most reduced inorganic form of N in water. Analysis of water samples normally includes ionized ammonia (ammonium NH4-N) and unionized ammonia (NH3) with results expressed as total ammonia N. N fixing organisms (algae, bacteria, etc.) living in symbiotic association with plants in soil or water reduce (elemental) N to NH3 and the NH4-N ion.

NH3 is a highly soluble compound resulting from either the decomposition of nitrogenous organic matter (plant or animal wastes) or the microbial reduction of NO_3-N or NO_2-N under anerobic conditions. NH3 associated with clay minerals enters the aquatic environment through soil erosion. Soils containing large amounts of vermiculitic or illitic type minerals have the capacity for fixing NH3 (Willrich, 1970). Commercial fertilizers to improve crop yields contain highly soluble NH3 and HN4-N salts. When the concentration of such compounds exceed the immediate plant requirements, precipitation of irrigation waters carry these nitrogen compounds into the aquatic system (McNeely, 1979). The animal wastes from feedlots and in other areas of contaminant can act as sources of NH3 in surface wastes.

NH3 is a non-persistent, non-cumulative toxic substance and in low concentrations present no physiological detriment to man or livestock. Fish cannot tolerate large quantities of NH3 since it reduces the oxygen carrying capacity of blood and thus the fish may suffocate (NcNeely, 1979). For general use waters, the Illinois Pollution Control Board (1977) specified that NH3 should not exceed 1.5 mg/l, while USEPA has recommended setting a limit of 0.02 mg/l on the unionized form NH3 for protection of aquatic life.

NH3 concentrations did not exceed the 1.5 mg/l limit established by the Illinois Pollution Control Board, only one sample exceeded, 10.0 mg/l. However, NH3-N concentrations at all three stations frequently exceeded the 0.02 mg/l limit that USEPA recommended during Water Year 1980 (Davenport, 1982B) and Water Year 1981 (Appendix Section).

TABLE 23

Mean, maximum, minimum and standard deviations of NH_3 concentrations for all stations by Water Year and analysis period in milligrams per liter.

		Station	
	A	B	C
1980 Water Year ($\bar{X}$)*	0.04	0.18	0.37
standard deviation	0.09	0.18	0.51
sample size	18	18	20
1981 Water Year ($\bar{X}$)	0.17	0.20	0.19
standard deviation	0.28	0.26	0.20
sample size	35	35	36
P1 -- 1980 ($\bar{X}$)	0.04	0.29	0.19
standard deviation	0.07	0.19	0.16
sample size	8	8	7
max	0.20	0.50	0.50
min	0.00	0.00	0.10
P1 -- 1981 ($\bar{X}$)	0.05	0.25	0.22
standard deviation	0.05	0.20	0.14
sample size	11	11	13
max	0.10	0.60	0.70
min	0.00	0.00	0.00
P2 -- 1980 ($\bar{X}$)	0.07	0.09	0.34
standard deviation	0.08	0.09	0.50
sample size	18	18	21
max	0.30	0.40	2.10
min	0.00	0.00	0.00
P2 -- 1981 ($\bar{X}$)	0.12	0.13	0.16
standard deviation	0.15	0.08	0.11
sample size	18	18	18
max	0.63	0.25	0.41
min	0.00	0.01	0.00
P3 -- 1980 ($\bar{X}$)	-0-	0.38	0.28
standard deviation		0.63	0.49
sample size		5	4
max		1.50	1.00
min		0.10	0.00

*May-September

Comparisons of averages with standard deviations for NH3 shows the extreme variations in stations and periods of analysis (Table 23). Figure 15 shows NH3 concentrations over time by station. NH3 concentration trends resemble those N32 at Stations A and B (Table 20, Figure 15). Biological conversion, subsurface contributions, and NH3 released into the stream through decomposition of organic debris possibly explain the increase in mean NH3 concentration during P2 at Station C during Water Year 1980. In 1981, during P2 the NH3 concentrations decreased this probable results from rainfall flushing the available NH3 during P1.

NH3 concentrations trends measured at Station C resemble those of PTL (Table 18) measured at Station C. The interrelationship of Kennedy's (1972) concept of relative time and Wallings (1975) concept of subsurface flushing explain the higher NH3 concentrations measured after rainfall events. Most of the rainfall during this period was infiltrated into the soil and resulted in streamflow (Table 11). The newly infiltrated rain displaces and mixes with residual soil water that has been in contact with soil this percolates to the stream course, resulting in lower NH3 concentrations in the streamflow because of less time in contact with the soil. This contribution occurs, thru the baseflow component, during the receding streamflow level of rainfall induce runoff. This agrees with Weart and Musgrave (1957) findings of NH3-N in a number of Illinois groundwater wells.

Stations B and C showed increased mean NH3 concentrations during P3 when compared to P2. The reducing environment and assimilation of NO3-N by biological organisms explains the increase of mean NH3 concentration from Station C to B. Large quantities of sediment and organic matter have settled out at Station B due to the flow constricting structure located there. The relationship of NH3 concentrations between Stations B and A resembles that of N32 (Table 22) due to similar reasons.

Potassium (KTL)

Potassium (KTL) is an essential element for plant and animal nutrition. Most soils are lacking in adequate amounts of available KTL. KTL is an alkali metal. In response to weathering after leaching, KTL usually is incorporated into new stable minerals (clay). KTL is a principal component of some fertilizers. KTL is a monovalent cation involved primarily in ion transport and exchange.

The concentration of KTL in natural surface water seldom reaches 20 mg/l and is generally less than 10 mg/l (McNeely, 1979). The rather narrow range of concentration of KTL observed in natural water suggests a significant chemical control mechanism may be involved (Hem, 1979). KTL usually is not connected with water pollution.

KTL concentrations decreased significantly at Station C between Water Years 1980 and 1981 (Table 24). This decrease is probably due to increased leaching bringing available KTL ions in contact with minerals which could incorporate them into their structure. The narrow range of concentration at Station B could result from the effects of the flow construction structure stabilizing lake inflow and the potential chemical interactions with the bottom sediments. Elevated KTL concentrations after rainfall runoff events would indicate groundwater flushing or high interflow contributions to streamflow, if the KTL ions were not complexed.

In comparison, KTL concentrations measured at Station B and C increases during P2, at Station A there was not a significant difference. Laterally, between Stations, there was a significant increase in KTL concentrations between Stations C and B for all analysis periods during 1981.

TABLE 24

Mean, maximum, minimum, and standard deviations of KTL concentrations for all stations by Water Year and analysis period in milligrams per liter.

		Station	
	A	B	C
1980 Water Year ($\bar{X}$)*	5.04	5.13	6.43
standard deviation	2.14	0.60	4.65
sample size	21	21	20
1981 Water Year ($\bar{X}$)	5.17	5.30	4.21
standard deviation	0.59	1.51	2.08
sample size	35	35	35
P1 -- 1980 ($\bar{X}$)	5.84	5.08	3.03
standard deviation	2.99	0.51	1.06
sample size	8	8	7
max	13.00	6.10	4.60
min	3.70	4.50	1.80
P1 -- 1981 ($\bar{X}$)	5.34	5.07	3.62
standard deviation	0.45	1.08	1.93
sample size	13	13	13
max	5.90	7.60	9.60
min	4.10	3.30	2.30
P2 -- 1980 ($\bar{X}$)	4.76	5.42	7.44
standard deviation	1.10	0.90	4.10
sample size	21	21	21
max	5.90	7.60	21.00
min	0.60	4.30	3.10
P2 -- 1981 ($\bar{X}$)	4.87	5.28	4.40
standard deviation	0.57	2.02	2.12
sample size	16	16	17
max	5.70	11.00	11.00
min	3.40	0.70	2.40
P3 -- 1980 ($\bar{X}$)	5.64	5.68	3.64
standard deviation	0.18	3.38	2.44
sample size	5	5	5
max	5.80	11.60	8.00
min	5.40	3.40	2.30

*May-September

Fecal

Fecal coliform (FC) and streptococcus (FS) are being measured at Stations A, B, C and J as part of the Blue Creek Watershed project. FC bacteria although not harmful in themselves, indicate that a potential hazard to human health exists. Water with FC bacteria may contain fecal matter that can transmit disease causing bacteria and viruses.

The ratio of FC to FS is used to determine if pollution is from human or animal feces. Estimated per capita contributions of FC and FS for animals were used to develop the following FC/FS ratios: (APHA, 1980).

Species	Ratio
Human	4.4
Duck	0.6
Sheep	0.4
Chicken	0.4
Pig	0.4
Cow	0.2
Turkey	0.1

A ratio greater than 4.1 is considered indicative of pollution derived from domestic wastes composed of human excrement whereas ratios less than 0.7 suggest pollution due to non-human sources. Ratios between 0.7 and 4.1 usually indicate wastes of mixed human and animal sources.

Table 25 shows the mean and standard deviations of FC and FS by station, by Water Year and individual measurements. FC concentrations exceeded the 200/100 ml level set by the Illinois Pollution Control Board at various times and all sites; 9 times (total 33) Station A, 24 times (total 34) Station B and 25 times (total 33) Station C during Water Year 1981. Table 26 shows the number of samples and percentages by FC/FS ratio for Water Years 1980 and 1981. The FC:FS ratios indicates wastes of mixed human and animal sources.

TABLE 25

Mean, standard deviations and number of F.C. and F.S. samples for Stations A, B and C by Water Year and analysis period in # per 100 mls.

	A		B		C	
	F.C.	F.S.	F.C.	F.S.	F.C.	F.S.
Water Year 1980 $(\bar{X})$	467.4	270.5	702.3	608.2	13494.0	1015.0
standard deviation	1687.1	633.5	1049.4	1337.9	41556.0	3722.0
sample size	19	19	19	19	19	19
Water Year 1981 $(\bar{X})$	294.2	181.8	2017.7	2751.6	3485.3	1608.8
standard deviation	531.3	310.6	3538.3	7462.3	5894.8	4010.9
sample size	33	33	34	34	34	34
P1 -- 1980 $(\bar{X})$	143.8	81.4	894.8	1095.7	4207.0	3690.0
standard deviation	249.6	184.6	1531.3	2057.3	6920.9	5380.3
sample size	8	8	8	8	8	8
P1 -- 1981 $(\bar{X})$	335.8	311.7	372.33	6278.3	4625.0	3594.2
standard deviation	521.8	452.9	5419.7	11917.0	4832.5	6391.2
sample size	12	12	12	12	8	8
P2 -- 1980 $(\bar{X})$	702.4	312.4	959.0	458.3	13257.0	10316.0
standard deviation	1829.8	640.8	1266.7	1108.2	42698.0	38376.0
sample size	17	17	18	18	18	18
P2 -- 1981 $(\bar{X})$	378.7	281.3	3491.3	1043.3	3818.0	1246.0
standard deviation	738.5	663.8	8815.4	1898.8	7434.1	1946.2
sample size	15	15	15	15	15	15
P3 -- 1980 $(\bar{X})$	108.3	91.7	793.3	1675.0	263.3	503.3
standard deviation	240.9	200.0	1209.9	1850.2	557.9	599.9
sample size	6	6	6	6	6	6

TABLE 26

Number of samples by FC/FS ratio by station and Water Year. Percentage in parenthesis.

	FC/FS		
	<0.7	0.7 to 4.1	4.1>
Station A -- 1980	4 (50.0)	2 (25.0)	2 (25.0)
-- 1981	6 (30.0)	9 (45.0)	5 (25.0)
Station B -- 1980	2 (13.3)	11 (73.3)	2 (13.3)
-- 1981	4 (14.9)	13 (48.1)	10 (37.0)
Station C -- 1980	1 (6.7)	12 (80.0)	2 (13.3)
-- 1981	6 (21.4)	12 (42.9)	10 (35.7)
Total -- 1980	7 (18.4)	25 (65.7)	6 (15.8)
1981	16 (21.4)	34 (45.3)	25 (33.3)
Combined	23 (20.4)	59 (52.2)	31 (27.4)

Organic Matter Demand

Organic matter in natural waters includes a great variety of organic compounds. Collective parameters, such as chemical oxygen demand (COD) and biological oxygen demand (BOD) are used to estimate the total quantity of organic matter present.

BOD is a measure of the amount of oxygen required by microorganisms to decompose the organic matter in a water sample under a specific set of conditions. COD is a measure of the total amount of oxygen which is required to completely oxidize all of the organic matter in a sample to carbon dioxide and water.

The COD of water increases with increasing organic matter concentrations COD may also be used to estimate BOD. COD exceeds the BOD of water due to inability of aerobic bacteria to completely oxidize the more resistant organic constituents under the conditions of the BOD test.

In addition to oxygen depletion and resulting changes in aquatic life, decomposing organic matter contributes or causes color, taste, and odor problems in surface water. Such problems are difficult to solve, yet their impact upon people are highly significant.

BOD is not a pollutant itself, but it is a measure of organic pollution. A BOD load can pose a threat to the aquatic environment by depressing the dissolved oxygen concentrations to levels that affect aquatic organisms. BOD levels less than 4.0 mg/l are deemed reasonably clean waters. Waters with levels greater than 10.0 mg/l thus are considered polluted since they contain large amounts of degradable organic matter (McNelly, 1979).

It seems fairly self evident that the oxygen demand of the dissolved and particulate organic matter accounts in large measure for oxygen concentrations of less than 100 percent saturation. The BOD level measured at Station A during Water Years 1980 and 1981 did not exceed 10.0 mg/l. At Station A from October, 1980 to May 20, 1981 BOD did not exceed 5.0 mg/l. BOD levels exceeded 10 mg/l on four occasions at Stations B and once at Station C. These occurred after periods of intense, large runoff producing storm events. The highest BOD value was recorded at Station B (38.0 mg/l) on May 26, 1981. Mean BOD values at Station B were the highest of all three stations during Water Years 1980 and 1981, this results from the flow constriction device (bridge) there.

TABLE 27

Mean, maximum, minimum and standard deviations of BOD values for all stations by Water Year and analysis period in milligrams per liter.

		Station	
	A	B	C
1980 Water Year ($\bar{X}$)*	5.05	9.32	7.05
standard deviation	2.91	11.90	4.85
sample size	20	20	20
1981 Water Year ($\bar{X}$)	4.65	7.07	4.50
standard deviation	1.51	5.87	3.20
sample size	37	38	36
P1 -- 1980 ($\bar{X}$)	6.57	6.00	4.57
standard deviation	2.76	2.24	1.27
sample size	7	7	7
max	10.0	9.0	6.0
min	4.0	4.0	3.0
P1 -- 1981 ($\bar{X}$)	5.23	9.54	5.08
standard deviation	1.83	8.92	4.59
sample size	13	13	13
max	9.0	37.0	20.0
min	3.0	4.0	2.0
P2 -- 1980 ($\bar{X}$)	3.86	4.67	6.86
standard deviation	1.11	1.43	4.96
sample size	21	21	21
max	7.0	7.0	18.0
min	2.0	2.0	2.0
P2 -- 1981 ($\bar{X}$)	4.83	7.17	3.82
standard deviation	0.92	2.41	1.74
sample size	18	18	17
max	7.0	13.0	7.0
min	4.0	4.0	2.0
P3 -- 1980 ($\bar{X}$)	3.00	5.00	3.80
standard deviation	1.22	3.94	2.95
sample size	5	5	5
max	5.0	12.0	9.0
min	2.0	3.0	2.0

*May-September

COD may reduce dissolved oxygen levels, thus affecting the survival of aquatic organisms, but no water quality guidelines for COD have been proposed. Comparisons of means with standard deviations for COD shows the extreme variations in stations and periods of analysis (Table 28) during Water Years 1980 and 1981. Station C values had the most variation. Whereas the variation at Stations A and B was minimal. The peak values at Station C were measured after intense rainfall event. There was significant difference between all analysis periods at Station C. The P1 value was the highest value during Water Year 1981, this probably results from the large amount of rainfall occurring on the distributed cropland and organic matter being transported to the stream. P3 has the next highest value, this is the residue management period when large amounts of residue are available for transport but the transporting agent (rainfall) is the limiting. There is a significant decrease in COD values from Station B to A, this results from natural limonological process occurring in the lake. The COD data is listed in the Appendix Section. COD values are significantly higher than BOD values.

TABLE 28

Mean, maximum, minimum and standard deviations of COD values for all stations by Water Year and analysis period in milligrams per liter.

	Station		
	A	B	C
1980 Water Year ($\bar{X}$)*	20.40	25.80	30.60
standard deviation	3.65	4.33	26.50
sample size	21	21	20
1981 Water Year ($\bar{X}$)	23.60	40.90	227.00
standard deviation	21.30	63.00	237.00
sample size	58	47	101
P1 -- 1980 ($\bar{X}$)	22.00	27.50	15.43
standard deviation	4.54	4.28	4.54
sample size	8	8	7
max	30.0	36.0	23.0
min	21.0	23.0	11.0
P1 -- 1981 ($\bar{X}$)	22.10	59.56	305.78
standard deviation	4.35	97.60	265.82
sample size	29	18	59
max	26.0	445.0	1350.0
min	14.0	22.0	10.0
P2 -- 1980 ($\bar{X}$)	18.24	23.81	31.43
standard deviation	2.77	4.19	25.61
sample size	21	21	21
max	25.0	34.0	121.0
min	15.0	16.0	13.0
P2 -- 1981 ($\bar{X}$)	28.52	47.88	165.51
standard deviation	33.57	81.25	171.85
sample size	23	24	37
max	180.0	420.0	550.0
min	15.0	14.0	8.0
P3 -- 1980 ($\bar{X}$)	19.20	30.60	181.43
standard deviation	3.42	28.85	131.04
sample size	5	5	14
max	23.0	82.0	345.0
min	14.0	14.0	12.0

*May-September

Heavy Metals, Trace Elements and Pesticides

While most trace elements occur naturally in the environment, extensive use of metals in industry often results in concentrations greatly exceeding natural levels. Certain heavy metals are known to be highly toxic to aquatic organisms and cumulative in the food chain (Hesse, 1972). Because accumulation of heavy metals may result in complex changes in the structure and stability of aquatic ecosystems (McFarlane, 1978) a multitude of studies have been conducted to document metal accumulation in aquatic environment (Hesse, 1972; Kleinert et al. 1974; and Matlus, 1971) (Sefton, 1980). All heavy metals and related trace elements were analyzed monthly at Stations A, B and C; except iron and potassium which was analyzed as part of the weekly water quality sampling program.

Calcium (Ca)

Ca is one of the alkaline-earth metals and one of the most abundant cations in surface and groundwaters. Since Ca is relatively abundant in the earth's crust and is readily soluble in water, ions and salts are frequently encountered in water. The presence of Ca in fesh waters varies according to the proximity of natural sources. Typical Ca concentrations are less than 15 mg/l, while waters close to carbonate rocks may be in the range of 30 to 100 mg/l.

Ca is essential to human nutrition. High concentrations in water are relatively harmless to all organisms and may reduce toxicity of certain chemical compounds to fish. Guidelines for Ca concentrations in drinking water have been established not for health reasons but rather to alleviate the adverse tendency of Ca to contribute to water hardness. An acceptable limit of 200 mg/l has been proposed for waters used for drinking with objective concentrations less than 75 mg/l. Drinking waters used for livestock may contain as much as 1000 mg/l, but should magnesium be present a limit of 700 mg/l is probably desirable for beef (McNeely, 1979).

TABLE 29

Mean Ca concentrations in milligrams per liter by station and Water Year, number of observations in parenthesis.

	Station		
	A	B	C
Water Year 1980 ($\bar{X}$)	27.0 (3)	31.0 (3)	59.0 (30
Water Year 1981 ($\bar{X}$)	28.0 (2)	37.0 (2)	70.0 (2)

There appears to be an "upstream-downstream" trend in mean Ca concentrations during Water Years 1980 and 1981. Due to the low number of observations no test of significance were performed. The differences in mean Ca concentrations at all station between water years 1980 and 1981 probably result from 41% increase in precipitation from 1980 to 1981.

Magnesium (Mg)

Mg, an alkaline-earth metal, is an abundant element and a common constituent of natural waters. Mg concentrations in water are highly variable ranging from 1 mg/l to 100 mg/l, especially when proximal to its natural sources. Mg is non-toxic and poses no concern to public health or to aquatic life. Based on palatability, the maximum acceptable concentration is 150 mg/l. Concentrations greater than 50 mg/l induce mild laxative effects on people unaccustomed to that water source (McNeely, 1979).

TABLE 30

Mean Mg concentrations in milligrams per liter by station
and Water Year.
Number of observations in parenthesis.

		Station	
	A	B	C
Water Year 1980 ($\bar{X}$)	14.0 (3)	15.0 (3)	28 (30
Water Year 1981 ($\bar{X}$)	12.0 (2)	16.0 (2)	34.0 (2)

There appears to be an "upstream-downstream" trend in mean Mg concentrations during Water Years 1980 and 1981. Due to the low number of observations no test of significance were performed. There does not appear to be a pattern in Water Year differences.

Sodium (Na)

Na, the principal metal, is found in an ionic form in all surface waters. Nearly all Na compounds are readily soluble in water and tend to remain in aqueous solution. Na is an important cation and significant in the balance of total cations. All natural waters contain Na. The Na concentrations ranges from 1 mg/l to 100,000 mg/l. Na in irrigation waters adversely affects soil structure by replacing Ca and Mg.

TABLE 31

Mean Na concentrations in milligrams per liter by station and Water Year.
Number of observations in parenthesis.

	Station A	Station B	Station C
Water Year 1980 $(\bar{X})$	5.0 (3)	5.0 (3)	9.0 (3)
Water Year 1981 $(\bar{X})$	3.8 (2)	4.7 (2)	10 (2)

Barium (Ba)

Ba, an alkaline-earth metal, is usually found in only trace amounts in natural surface and groundwaters. Ba ions in natural water are precipitated or removed by sorption. Both sulphate and carbonate ions limit the concentration of Ba in water by causing its precipitation. Ba concentrations in surface water are sometimes as high as 0.34 mg/l (McNeely, 1979).

The Illinois Pollution Control Board (1977) has established a general use standard of 5.0 mg/l for Ba. Ba in concentrations greater than trace quantities may be toxic to plants. Ba may also adversely affect rooted aquatic plants and many species of fish. Concentrations greater than 5.0 mg/l are harmful to many species of fish (McNeely, 1979).

Comparisons of mean concentrations of Ba (Table 24) indicates the extreme variations in stations and Water Years. There appears to be an "upstream-downstream" trend in mean Ba concentrations. Station C's values were the highest and Station A's values the lowest.

TABLE 32

Mean Ba concentrations in micrograms per liter by station and Water Year.
Number of observations in parenthesis.

	Station A	Station B	Station C
Water Year 1980 ($\bar{X}$)	66.0 (3)	91.0 (3)	200.0 (3)
Water Year 1981 ($\bar{X}$)	61.0 (2)	65.0 (2)	131.0 (2)

Due to the low number of observations no test of significance were performed. Ba concentrations during Water Year 1980 and 1981 did not exceed the general use standard.

Beryllium (Be)

Be is a trace element that does not usually occur in natural waters. Be is usually present in concentrations less than 0.001 mg/l. Be and its compounds are extremely toxic to man; however, no guidelines have been proposed for drinking waters. At low levels Be is highly toxic to plants, since it inhibits photosynthesis. Irrigation waters, therefore, should generally not contain concentrations greater than 0.10 mg/l Be, although the maximum level permissible is 0.50 mg/l on fine textured neutral or alkaline soils (McNeely, 1979).

Table 33 shows the mean Water Year concentrations of Be by stations. Due to the low number of observations, no test of significance were performed.

TABLE 33

Mean Be concentrations in micrograms per liter by station
and Water Year.
Number of observations in parenthesis.

	Station		
	A	B	C
Water Year 1930 $(\bar{X})$	* (3)	1.0 (3)	* (3)
Water Year 1981 $(\bar{X})$	23.0 (2)	24.0 (2)	* (2)

*detectable in all samples, but not measurable

Boron (Bo)

Bo occurs in water as Na or Ca borate in relatively small quantities. In surface waters, the mean concentration of Bo is 0.1 mg/l. However, concentrations of up to 4.0 mg/l have been recorded in surface water during the winter when groundwater inputs constitute a large portion of the total streamflow, since groundwater may contain in excess of 4.0 mg/l (McNeely, 1977).

The Illinois Pollution Control Board (1977) has established a general use standard of 1.0 mg/l for Bo. A maximum Bo concentration of 5.0 mg/l is recommended for livestock drinking water (McNeely, 1977).

During Water Year 1980, Bo was detectable but not measurable. At Stations A, B and C, Bo was measurable in the winter Water Year 1981 runoff sample. It was also measurable in the summer Water Year 1981 runoff sample. There is no clear cut trend in Bo concentrations.

TABLE 34

Mean Bo concentrations in micrograms per liter by station and Water Year.
Number of observations in parenthesis.

	Station A	Station B	Station C
Water Year 1980 ($\bar{X}$)	* (3)	* (3)	* (3)
Water Year 1981 ($\bar{X}$)	19.0 (2)	18.0 (2)	26.0 (2)

*detectable in all samples, but not measurable

Cadmium (Cd)

Cd and its compounds are usually only present in waters in trace quantities. Natural waters contain only traces of Cd, in the range of 0.0001 to 0.010 mg/l (McNeely, 1977).

The Illinois Pollution Control Board (1977) has established a general use standard of 0.05 mg/l for Cd. Waters used for watering of livestock should not exceed 0.01 mg/l of Cd (McNeely, 1977). The aquatic environment is sensitive to high Cd concentrations. To protect aquatic life a maximum concentration of Cd has been set for 0.0002 mg/l (International Joint Commission, 1977).

Cd was not measured in any sample collected during Water Years 1980 and 1981.

Chromium (Cr)

Few waters contain Cr from natural sources because natural chromaters are rare. Freshwater concentrations of C are very low, usually less 0.001 mg/l. Cr is used in some fertilizers and in pesticides (McNeely, 1977).

The Illinois Pollution Control Board (1977) established a general use standard of 1.0 mg/l for Cr. USEPA (1976) recommends that Cr concentrations in raw and public drinking water not exceed 0.05 mg/l. To prevent harmful effects on livestocks drinking waters should be limited to 1.0 mg/l or less (McNeely, 1977). A maximum concentration of 0.05 mg/l has been recommended to provide adequate protection for both freshwater invertebrates and fish (International Joint Commission, 1977).

Cr was only measurable at Stations B & C during Water Year 1980, it was detectable at all stations but not measurable during Water Year 1981. Fertilizers and pesticides are the most likely sources of the measured Cr. Cr was measurable only in July, during the period preceeding this land management activities such as fertilization were occurring.

Cobalt (Co)

Co, a heavy metal, has similar chemical characteristics to nickel, but is more soluble than nickel in water. Natural surface water usually contains less than 0.0001 mg/l Co.

The level of Co in livestock drinking water should not exceed 1.0 mg/l. Since Co has a low toxicity to man, there are no water quality guidelines for Co in public drinking water (McNeely, 1977).

Co was not measurable in any sample taken during Water Years 1980 and 1981. It was detectable at all Stations.

Copper (Cu)

Cu is a common heavy metal constituent of natural waters. It is essential for plant and animal nutrition. Cu is generally present only in trace amounts in natural surface waters up to concentrations of 0.05 mg/l. It has been found that groundwaters may accumulate 12.0 mg/l.

To limit toxic reactions of plants, Cu concentrations in irrigation waters should be 0.2 mg/l for continuous use on all soil types. The upper limit for Cu in livestock waters is recommended to be 0.5 mg/l. For the protection of aquatic freshwater organisms a maximum acceptable concentration of 0.005 mg/l of Cu in water has been suggested (McNeely, 1977). The Illinois Pollution Control Board (1977) has established a general use standard of 0.02 mg/l for Cu.

TABLE 35

Mean Cu concentrations in milligrams per liter by station
and Water Year.
Number of observations in parenthesis.

	Station		
	A	B	C
Water Year 1980 $(\bar{X})$	0.01 (3)	0.01 (3)	0.01 (3)
Water Year 1981 $(\bar{X})$	* (2)	* (2)	* (2)

*detectable in all samples, but not measurable

Table 35 shows the mean Cu concentrations by Water Year and Station. Cu was only measurable in 1980 Water Year samples. No sample concentraion exceeded the Illinois general use standard.

Iron (Fe)

Fe is the fourth most abundant element in the earth's crust. Concentrations of Fe in aerated surface waters are usually less than 0.5 mg/l but can be substantially greater in groundwater and in thermal hot springs where concentrations may range from 10.0 to 100.0 mg/l (McNeely, 1977).

The Illinois Pollution Control Board (1977) has established a general use standard of 1.0 mg/l for Fe. A level of 0.3 mg/l total Fe has been recommended for the protection of the aquatic environment by the Great Lakes Quality Board (1976). Fe is highly objectionable for drinking water, concentrations of less than 0.05 mg/l are potable (McNeely, 1977).

Concentrations of Fe were determined for each weekly streamflow sample and averaged by Water Year, period of analysis and station. These data are summarized in Table 36. Comparisons of averages with standard deviations for Fe shows the extreme variations in stations and analysis periods.

TABLE 36

Mean Fe concentrations in milligrams per liter by station and Water Year.
Number of observations in parenthesis.

	Station		
	A	B	C
Water Year 1980 ($\bar{X}$)	0.30	2.37	4.48
standard deviation	0.23	1.70	8.38
sample size	21	21	20
Water Year 1981 ($\bar{X}$)	0.52	1.95	1.12
standard deviation	0.71	1.95	1.12
sample size	38	35	35
P1 -- 1980 ($\bar{X}$)	0.28	2.82	2.03
standard deviation	0.22	2.30	1.39
sample size	8	8	7
P1 -- 1981 ($\bar{X}$)	0.68	2.44	1.62
standard deviation	0.73	2.27	1.03
sample size	13	13	13
P2 -- 1980 ($\bar{X}$)	0.35	1.75	3.87
standard deviation	0.22	1.10	8.32
sample size	21	21	21
P2 -- 1981 ($\bar{X}$)	0.58	1.35	5.33
standard deviation	0.85	1.35	6.11
sample size	16	16	15
P3 -- 1980 ($\bar{X}$)	0.18	2.32	1.24
standard deviation	0.11	2.88	1.74
sample size	5	5	5

There is a distinct "upstream-downstream" trend exhibited by the mean Fe concentrations. Station C has the highest values and Station A the lowest. The difference between Stations are significant in all cases except during P1-1981 at Stations B and C. The difference Water Year and P2 differences result from the 42% increase in rainfall between Water Year 1980 and 1981.

Mean Fe concentrations at Stations B and C exceeded the general use standard for all analysis periods and both Water Years. Mean Fe concentrations never exceed the 1.0 mg/l general use standard.

Lead (Pb)

Pb is ubiquitous in the natural environment and may be found in both soluble and suspended forms in water. Generally low concentrations (trace to 0.04 mg/l) of Pb are found in water owing to its low solubility. Pb is a toxic material that accumulates in the skeletal structure of man and animals (McNeely, 1977).

The Illinois Pollution Control Board (1977) has established a general use standard of 0.1 mg/l for Pb. To protect livestock from adverse effects resulting from the accumulation of lead in their bodies, a limit of 0.1 mg/l has been recommended for livestock drinking water. The recommended levels of irrigation waters have been set at 10.0 mg/l for neutral and alkaline soils and 5.0 mg/l for acidic soils. To protect livestock from adverse effects resulting from the accumulation of Pb in their bodies, a limit of 0.1 mg/l has been recommended for livestock drinking water. The recommended levels of irrigation waters have been set at 10.0 mg/l for neutral and alkaline soils and 5.0 mg/l for acidic soils. To protect freshwater aquatic life a limit of 0.03 mg/l is recommended (McNeely, 1977).

Pb was not detected in any sample collected during Water Years 1980 and 1981.

Manganese (Mn)

Mn, a metallic cation, is similar to Fe in its chemical behavior and is frequently found in association with Fe. Mn is not usually present in appreciable concentrations in surface waters. It seldom reaches concentration of 1.0 mg/l in natural surface waters and is usually present in quantities of 0.2 mg/l or less (Hem, 1975).

Mn is an essential element for the nutrition of both humans and animals. It is an essential element for plant metabolism. After plants die, the Mn which accumulates within them is available for re-solution in runoff and in soil moisture. (McNeely, 1977).

The Illinois Pollution Control Board (1977) has established a general use standard of 1.0 mg/l for Mn. It is improbable that any waters used by livestock for drinking may reach toxic levels and no limits have been suggested. Irrigation waters for use on acid soils should not exceed 0.2 mg/l of Mn, while waters containing 10.0 mg/l may be used on neutral on alkaline soils (McNeely, 1977).

Comparisons of mean concentrations (Table 37) indicates the extreme variations in stations and Water Years. There appears to be "upstream-downstream" trend in mean Mn concentrations.

TABLE 37

Mean Mn concentrations in milligrams per liter by station
and Water Year.
Number of observations in parenthesis.

	Station A	 B	 C
Water Year 1980 ($\bar{X}$)	0.04 (3)	0.30 (3)	0.99 (3)
Water Year 19881 ($\bar{X}$)	0.16 (2)	0.28 (2)	0.56 (2)

Due to the low number of observations no test of significance were performed. Mn concentrations during Water Years 1980 and 1981 did not exceed the general use standard.

Nickel (Ni)

Ni in water may be found in a colloidal state; however, salts such as Ni ammonium sulphate, Ni nitrate, and chloride are soluble in water. The median freshwater concentration of Ni in North American rivers is 0.1 mg/l, although concentrations are often undetectable.

The Illinois Pollution Control Board (1977) has established a general use standard of 1.0 mg/l for Ni. There are no recommended livestock watering guidelines for Ni. Since Ni toxicity may occur in some plants at concentrations as low as 0.5 mg/l, the recommended maximum Ni concentration in irrigation waters for continuous use on most soils is 0.2 mg/l, but neutral fine-textured soils can accommodate 2.0 mg/l Ni (NcNeely, 1977). In order to protect sensitive aquatic life the recommended maximum permissible concentration of Ni in unfiltered water is 0.025 mg/l (Great Lakes Water Quality Board, 1976).

Ni was only measurable at Station C during Water Years 1980 and 1981 and it was detectable at the other Stations during Water Years 1980 and 1981. The two values measured at Station C were 0.01 and 0.007 mg/l.

Silver (Ag)

Ag occurs only in trace amounts in water. Freshwater concentrations of Ag usually range from 0.0002 to 0.039 mg/l. Ag is neither essential nor beneficial to plants and animals (McNeely, 1979).

The Illinois Pollution Control Board (1977) has established a general use standard of 0.005 mg/l for Ag. Ag was not measured in any sample during Waters Years 1980 and 1981.

Strontium (St)

St is a alkaline-earth metal that is chemically similar to Ca. In most surface waters, St is less abundant than Ca. This was exhibited in Blue Creek Watershed (Table 21 and 30). Most natural surface contains only a few mg/l although value up to 39 mg/l have been recorded in well samples (McNeely, 1977).

Comparisons of mean St concentrations (Table 38) indicate the variations in stations and water years. There appears to be an "upstream-downstream" trend in mean St concentration.

TABLE 38

Mean St concentrations in milligrams per liter by station and Water Year.
Number of observations in parenthesis.

	Station A	Station B	Station C
Water Year 1980 ($\bar{X}$)	0.06 (3)	0.06 (3)	0.12 (3)
Water Year 1981 ($\bar{X}$)	0.07 (2)	0.08 (2)	0.13 (2)

Due to the low number of observations no test of significance were performed. The Water Year difference could result from the 42% increase in rainfall between the Water Years.

Vanadium (Vn)

Vn concentrations in surface water may be as high as 0.3 mg/l although they are usually less than 0.05 mg/l. Low concentration of Vn are not toxic to man. The recommended limit for livestock drinking waters is 0.1 mg/l. Irrigation water on most soils should be limited to 0.1 mg/l. Vn, whereas on neutral and alkaline fine textured soil levels of 1.0 mg/l are allowable (McNeely, 1977).

Vn was only measurable at Stations B and C during Water Year 1980. It was not measurable during Water Year 1981 at any station.

Zinc (Zn)

Usually Zn is present in trace amounts in both ground and surface waters (i.e., less than 0.05 mg/l). Fertilizers and pesticides are sources of zinc to the environment. Zn is an essential element for plants, animals, and man because it is necessary for the functioning of certain enzymes. Zn is relatively non-toxic to man.

The Illinois Pollution Control Board has established a general use standard of 1.0 mg/l for Zn. In water used for livestock watering it is recommended that Zn concentrations not exceed 25 mg/l (McNeely, 1977). Great Lakes Water Quality Board (1976) has proposed that Zn concentrations should not exceed 0.03 mg/l in unfiltered water in order to protect aquatic life.

Comparisons of mean Zn concentrations (Table 39) indicates the extreme variation in stations and water years. There appears to be an "upstream-downstream" trend in mean Zn concentrations.

TABLE 39

Mean Zn concentrations in milligrams per liter by station and Water Year.
Number of observations in parenthesis.

	Station A	Station B	Station C
Water Year 1980 ($\bar{X}$)	0.01 (3)	0.02 (3)	0.03 (3)
Water Year 1981 ($\bar{X}$)	0.02 (1)	0.0 (1)	0.02 (1)

Due to the low number of observations no test of significance were performed. Zn concentrations did not exceed the general use standard, but at Station C they exceeded the recommended level to protect aquatic life twice.

Lithium (Li)

Li, one of the alkali group of metals, is not abundant in nature. Most surface waters contains less than 10 mg/l (Hem, 1975).

Li was measured at all three stations during Water Year 1980. It exhibits an "upstream-downstream" trend with Station C recording the highest value (0.25 mg/l) and Station A the lowest (0.15 mg/l).

Mercury (Hg)

Hg is a trace metal in the earth's crust and occurs in only minor quanitities in natural waters. Concentrations of Hg in uncontaminated freshwater systems are typically 0.00005 ug/l. Hg based pesticides are used in agricultural activities. Hg compounds are highly toxic to man and animals. (McNeely, 1977).

The Illinois Pollution Control Board has established a general use standard of 0.0005 mg/l for Hg. The Hg general use standard was exceeded once, at Station B during Water Year 1981.

To protect livestock from adverse effects, it is recommended that Hg concentrations not exceed 0.01 mg/l (Environmental Studies Board, 1973). This level was exceeded once, at all three stations during Water Year 1981. Hg compounds are toxic to fish and other aquatic life. To protect aquatic life, the concentration of total Hg in unfiltered water should not exceed 0.0002 mg/l (International Joint Commission, 1977). The Hg values measured at Stations A and B during Water Year 1981 exceeded the 0.0002 mg/l limit.

Hg was not measured in any sample during Water Year 1980. The time period, during Water Year 1981, which Hg was measured corresponds to the time of the year pesticide applications occurs.

Specific Conductance

Specific Conductance (conductivity) is a numerical expression of a water's ability to conduct an electrical current. It is measured in microiemens per centimere (us/cm) corrected to a standard temperature, 25oC. Specific conductance provides a good indication of the changes in a water's composition. It is particularly sensitive to variations of dissolved solids, but provides no indication of the relative quantities of the various components. As more dissolved solids are added, the water's specific conductivity increases. Specific conductance in natural surface waters has been found to range from 50 to 1500 us/cm. Groundwater usually has elevated specific conductance (McNeely, 1979).

There is a definite "upstream-downstream" trend in mean specific conductance values. The variation in mean concentrations between years result from the differences in rainfall (Table 40) and implementation of conservation tillage systems.

TABLE 40

Mean and standard deviations of specific conductance by station, Water Year, and analysis period expressed in us/cm.

		Stations	
	A	B	C
Water Year 1980* $(\bar{X})$	229.0	324.5	502.1
standard deviation	114.5	65.2	99.8
Water Year 1981 $(\bar{X})$	285.6	362.8	625.4
standard deviation	58.5	125.0	87.0
P1 -- 1980 $(\bar{X})$	300.0	375.7	543.1
standard deviation	25.6	87.9	74.5
P1 -- 1981 $(\bar{X})$	309.8	404.8	631.1
standard deviation	27.3	87.0	76.7
P2 -- 1980 $(\bar{X})$	289.9	308.9	547.3
standard deviation	28.8	52.5	126.0
P2 -- 1981 $(\bar{X})$	236.9	277.6	613.8
standard deviation	49.8	65.1	104.9
P3 -- 1980 $(\bar{X})$	344.6	506.5	623.0
standard deviation	13.1	120.5	58.6

*only 5 month period

Dissolved Oxygen (DO)

Oxygen is one of the gases that is found dissolved in natural surface waters. The amount of DO in natural water varies since it is dependent upon temperature, salinity and turbulence of the water, and atmospheric pressure. The concentration of DO is subject to diurnal and seasonal fluctuations that are due, in part, to variations in temperature, photosynthesis activities and river discharge. Typically the concentration of DO in natural surface water is less than 10 mg/l (McNeely, 1979).

The DO content of water is an indicator of the biochemical condition of the water at that time and place. Fish and other desirable clean-water biota require relatively high DO levels at all times. Streams with large loads of organic material, however, may have oxygen -- consuming organic and inorganic reactions that deplete oxygen to levels unfavorable for the clean-water species. The DO content is an indication of the status of the water with respect to balance between oxygen-consuming and oxygen-producing processes at the moment of sampling (Hem, 1978).

TABLE 41

Mean and standard deviations of DO by station, Water Year, and analysis period expressed in mg/l.

		Stations	
	A	B	C
Water Year 1980* $(\bar{X})$	8.31	6.3	7.3
standard deviation	2.4	2.3	2.0
Water Year 1981 $(\bar{X})$	8.2	7.9	9.2
standard deviation	3.1	3.6	2.9
P1 -- 1980 $(\bar{X})$	10.4	5.9	8.2
standard deviation	4.2	1.9	1.7
P1 -- 1981 $(\bar{X})$	8.5	7.3	8.3
standard deviation	2.0	2.0	1.5
P2 -- 1980 $(\bar{X})$	8.8	7.8	8.5
standard deviation	2.0	2.8	3.1
P2 -- 1981 $(\bar{X})$	6.1	5.9	7.5
standard deviation	2.5	2.4	1.5
P3 -- 1980 $(\bar{X})$	12.8	12.3	14.0
standard deviation	1.2	1.3	1.3

*5 months (May-September)

Comparisons of means with standard deviations of DO shows the variations in stations and period analysis (Table 41) Stations A's DO concentrations ranged from 1.3 mg/l to 14.0 mg/l. Station B's DO concentrations ranged from 1.1 to 17.0 mg/l, at Station C it ranged from 5.3 to 14.8 mg/l. Station B's mean DO concentrations are depressed when compared to Station A and B's values. The lower values at Station B result from the combination of decreased water flow due to the flow constriction device, and the decomposition of settled organic matter.

Temperature

Temperature may be defined as the condition of a body which determines the transfer of heat to, or from, other bodies. Physical, biological and chemical processes in the aquatic environment are affected by temperature. Temperature variations are part of the natural climatic regime. Natural bodies of water may exhibit seasonal and diurnal variations. Aquatic organisms have both an upper and lower temperature limit for optional growth, spawning, egg incubation and migration. These limits vary from species to species.

Table 42 shows the mean and standard deviations of the temperature values by station, Water Year, and analysis periods. The temperature of a water is primarily a reflection of the climatic regime. Water Year 1980 was warmer than Water Year 1981 and this is reflected in the water temperature.

TABLE 42

Mean and standard deviations of temperature (^{o}C)
by station, Water Year and analysis period.

		Stations	
	A	B	C
Water Year 1980* ($\bar{X}$)	25.2	25.9	21.5
standard deviation	4.1	5.0	4.5
Water Year 1981 ($\bar{X}$)	18.2	16.7	13.4
standard deviation	7.3	7.8	6.7
P1 -- 1980 ($\bar{X}$)	22.0	22.3	18.7
standard deviation	3.8	4.8	4.2
P1 -- 1981 ($\bar{X}$)	19.9	19.8	16.3
standard deviation	4.3	4.4	3.6
P2 -- 1980 ($\bar{X}$)	21.6	21.8	17.3
standard deviation	8.3	9.4	8.5
P2 -- 1981 ($\bar{X}$)	20.2	20.1	16.5
standard deviation	6.0	6.5	5.6
P3 -- 1980 ($\bar{X}$)	6.7	6.6	5.2
standard deviation	2.5	2.8	2.5

* May-September, 1980

pH

pH indicates the balance between the acids and bases in water and is a measure of the hydrogen ion concentration in solution. pH values reflect the solvent power of water. A pH range from 6.5 to 8.3 units is acceptable in drinking and for the protection of the aquatic environment, the pH should be within the range of 6.5 to 9 units (International Joint Commissions, 1977).

Table 43 shows the mean and standard deviations of pH values recorded by station, Water Year and analysis period. Mean pH did not exceed the recommended drinking or aquatic protection range of pH values.

Table 43

Mean and standard deviations of pH by station, Water Year and analysis period

		Stations	
	A	B	C
Water Year 1980* $(\bar{X})$	8.1	7.9	7.3
standard deviation	0.8	1.1	1.0
Water Year 1981 $(\bar{X})$	7.9	7.8	7.6
standard deviation	0.4	0.3	0.2
P1 -- 1980 $(\bar{X})$	8.1	7.4	7.3
standard deviation	0.5	0.4	0.5
P1 -- 1981 $(\bar{X})$	8.2	7.9	7.6
standard deviation	0.3	0.4	0.1
P2 -- 1980 $(\bar{X})$	7.8	8.0	7.5
standard deviation	0.7	1.0	0.8
P2 -- 1981 $(\bar{X})$	7.8	7.9	7.6
standard deviation	0.4	0.3	0.2
P3 -- 1980 $(\bar{X})$	7.8	7.8	7.8
standard deviation	0.3	0.2	0.1

Runoff and Suspended Solid Transport

The storms included in Table 44 are ranked according to total storm flow, total suspended solids load and total precipitation. Most of the storms fall fairly well in order, with total precipitation corresponding with total load. The greatest exception is the storm event of July 19, which ranked third in total precipitation but ninth in total load. The storms on June 6 and July 25 show that equally intense rains do not necessarily produce equal quantities of suspended solids transport. The major reasons for this difference are the increased ground cover of the agricultural crops and the previous storms' runoff flushing the available supply of disturbed material that was propogated thru P1 (April-June) activities.

TABLE 44

Total precipitation, streamflow and suspended load transported by selected storm event at Station C. Ranking in parenthesis.

Date	Precipitation (in)		Streamflow (cfs-day)		Load tons/day	
10/17/80	1.71	(10)	35.4	(9)	1.7	(11)
04/11/81	2.17	(4)	28.0	(11)	338.0	(5)
05/10/81	1.99	(5)	31.5	(10)	178.0	(6)
05/18/81	2.70	(2)	253.9	(3)	1969.0	(4)
06/21/81	1.80	(8)	76.9	(8)	2233.0	(3)
06/24/81	1.94	(6)	124.2	(5)	3677.0	(2)
07/04/81	4.34	(1)	492.5	(1)	4588.0	(1)
07/19/81	2.63	(3)	122.0	(6)	36.8	(9)
07/25/81	1.78	(9)	97.3	(7)	21.8	(10)
07/26/81	1.93	(7)	402.9	(2)	84.6	(7)
07/27/81	1.65	(11)	239.7	(4)	46.5	(8)

The eleven storms included in Table 11 account for 73% of the total suspended solid load transported by Station C during Water Year 1981. Storms as defined by Wischmeier (1965) transported 94% of the total suspended solid load transported by Station C during Water Year 1981. It can be concluded from this data, that the bulk of erosion and transportation of suspended material from up land sites is related to a very small number of hydrologic events (11 out of 69) whose occurrence is dependent upon the development of specific meteorological conditions.

The importance of a small number of storm events makes climate variation critical to the explanation of variations in total suspended solid transport. A modest change in expected seasonal location of a storm track affects the number of occurrences of days with high magnitude sediment yields. Knox's (1977) concludes that climate changes of this type explain most of both the short and long term variations in sediment yields. During Water Year 1980 which had below normal precipitation; storms (Wischmeier definition) accounted for 32% of all rainfall events and 82% of the suspended solid load at station C; whereas during Water Year 1981 which had above normal precipitation; storms accounted same percentage of rainfall events but 94% of the suspended solid load. Total suspended solid load transported by station C during May thru September, 1980 was 2921.4 tons; while during the same period in 1981, 15,602.8 tons were transported.

Loadings

The mass of material being transported in suspension is called suspended load. The mass of material being transported in virtually continuous contact with the streambed is called bed load. The range in size and specific gravity of material transported for both modes of transport is tremendous. The estimates provided below are of the suspended load transported by each station.

The sediment load carried by a stream is a function of a number of variables. Sediment is defined as any solid material, either mineral or organic, that has been eroded, transported and deposited on land or in water (Haith, 1979). The major ones are:

1. The characteristics of the watershed, such as soils, land cover and agricultural practices.

2. The meteorological conditions, such as rainfall and runoff characteristics, and snow and ice melt.

3. Physical features, determined by land use and urbanization practices. The nature of the bed and bank material, soil cover, bank cover, and characteristics of the tributaries or drainage ditches.

4. Man-made constraints, river straightening and channelization, repair or maintenance of stream banks and levees, and construction of bridges (Station B) and dams (Station A) (Ivens, 1981).

The sediment yield of a draiage basin is the resultant of the processes of erosion, transportation and deposition operating in that basin, and its magnitude reflects the sediment delivery ratio. Sediment yield controls the channel pattern and aspects of channel geometry, such as the depth-width ratio (Morisawa, 1968). Significant changes in erosion and sediment transport often occur when an existing balance between land cover and climate is disrupted (Knox, 1977). Earlier estimates of the sediment delivery ratio for the Blue Creek Watershed range from 48% (Lee, 1981) to 66% (Davenport, 1982).

The yield per month from the watershed stations varied greatly during Water Year, 1980 and 1981 (Table 45). Figure 16 summarizes the yield per station per month of total suspended solid transported at all stations. Table 19 summarizes the total event and non-event transport at each station by Water Year and analysis periods. The time variation in loadings is caused mostly by: 1) seasonal variations in availability of material and rainfall; 2) snowmelt runoff versus thunderstorm runoff; 3) length of periods between rainfall-runoff events; and 4) differences between turbulence characteristics on rising and falling stages of streamflow.

Total suspended solids transport is time variant due to surface cover, precipitation patterns and land management activities (Table 45). During P1 (April-June) there is a high degree of soil disturbance, combined with severe thunderstorms, results in the majority of total suspended solids being transported during this period. During P2 the increased surface cover and infiltration of precipitation appeared to decrease suspended solids transport from cropland. Precipitation during P3 usually occurs as snowfall on frozen ground, that is covered with residue, so suspended solids transport was expected to be minor.

Total suspended solids transport (Table 45) showed a definite "upstream -- downstream" trend with lower quantities measured downstream. At Station C, (Figure 6) about 99% of total suspended solids transport during may through June, 1981 occurred during storm events; during July through September it was 98%. During Water Year 1981, about 98% of the total suspended solids transport occurred during storm events. Station B showed a similar relationship, but the total quantity measured was 26% of Station C's quantity. The flow construction device, a causeway and bridge at Station B, causes differential velocities in storm flow to occur between B and C, thus allowing the suspended matter to settle out from Station B has lost 95% of its sediment storage capacity due to accumulation.

An example of the importance in the variation in rainfall is between 1980 P1 and 1981 P1, when during P1-1980 74% of the rainfall came as storm events and totaled 8.96 inches and during P1-1981 86% of the rainfall came as storm events and totaled 19.15 inches. Table 47 shows the differences in loadings during these periods; 1980-P1 loadings were only 18% of that measured during 1981-P1. This difference is associated with the 53% difference in total rainfall and to the 12% increase in storm related precipitation.

TABLE 45

Monthly TSS load summary by station
within the Blue Creek
Watershed, May, 1980 -- September, 1981.
Monthly rainfall in Inches for the Watershed.

	Total Suspended Solids Load in Tons			
		Stations		
Month	A	B	C	Rainfall (in)
May	2.7	31.5	50.8	4.21
June	8.8	622.0	2351.0	2.55
July	0.0	1.2	0.6	1.35
August	1.2	57.9	179.0	4.11
September	5.4	57.8	340.0	5.03
October	1.5	6.8	2.0	3.00
November	0.0	0.6	0.1	0.50
December	1.2	48.0	29.6	0.25
January	0.0	0.0	0.0	0.63
February	0.0	2.3	0.0	1.22
March	8.7	5.0	33.8	2.35
April	113.0	216.0	2504.0	5.86
May	127.0	1420.0	2160.0	6.81
June	76.7	2269.0	8460.0	6.84
July	196.0	4742.0	4976.0	14.35
August	31.6	10.3	4.6	1.77
September	11.4	3.6	2.2	0.67
Total	585.2	9494.0	21093.7	61.50

Duration analysis can be employed to demonstrate that a large proportion of sediment load of a river is carried during a short period of time, Walling (1977) documented that for the Cass River, Michigan, approximately 80 percent of the suspended load was carried in 5 percent of the year. In the Blue Creek Watershed, during Water Year 1981 approximately 94 percent of the load transported by Station C within an overall duration equivalent to 22 days (6% of the year). During Water Year 1980, 82% of the load was transported in 9% of the measured time.

The seasonal distribution of yield at each station reflects the interaction of precipitation, flow regime, and sediment availability (surface cover). In June, 1980; 2351.0 tons of total suspended solids were transported past Station C and 2.55 inches of rainfall were measured. In March, 1981; 33.8 tons of total suspended solids were transported past Station C while 2.35 inches of rainfall were measured (Table 45). The 0.2 inch difference in rainfall doesn't fully explain the 2317.2 ton difference in total suspended solids transported. Table 46 shows the monthly distribution of total suspended yield at Station C in relation to the monthly flow regime and surface cover. The close dependence of suspended solid load on discharge should not be viewed as indicative of transport capacity effect, because wash load is essentially a non-capacity load, but rather that the erosion processes causing suspended solid entrainment generally operate most effectively during high flow. The load transported from October, 1980 to February, 1981 illustrates the exhaustion effect operating through a series of months (Table 46). Basically, this means the streamflow has transported the available material and the stream is functioning as closed system.

TABLE 46

Monthly distribution of yield and streamflow at Station C by analysis period.

Period	Month	Total Suspended Solids Load (Tons)	Streamflow (CFS-Days)
P1	May, 1980	50.8	35.7
	June, 1980	2351.0	59.1
P2	July, 1980	0.6	2.9
	August, 1980	179.0	23.7
	September, 1980	340.0	69.1
	October, 1980	2.0	40.1
	November, 1980	0.1	3.7
P3	December, 1980	29.6	22.2
	January, 1981	0.0	3.7
	February, 1981	0.0	23.9
	March, 1981	33.8	16.0
P1	April, 1981	2504.0	140.4
	May, 1981	2160.0	323.9
	June, 1981	8460.0	320.8
	July, 1981	4976.0	1575.7
	August, 1981	4.6	32.3
P2	September, 1981	2.2	18.7

TABLE 47

Total event and non-event suspended solids transport for each station by Water Year and analysis period in tons.

		Station A	Station B	Station C
Water Year-1980*	Total	18.16	770.42	2921.38
	Event	5.66	756.10	2904.62
	Non-Event	12.50	14.32	16.60
Water Year-1981	Total	568.00	8724.00	18,170.00
	Event	128.43	6482.14	17,821.50
	Non-Event	439.57	2241.86	348.50
P1-1980	Total	11.48	653.50	2401.80
	Event	4.52	643.40	2393.72
	Non-Event	6.96	10.10	8.08
P1-1981	Total	316.70	3905.00	13,124.00
	Event	81.85	3839.00	13,065.00
	Non-Event	234.85	66.00	59.00
P2-1980	Total	8.20	116.92	519.58
	Event	1.14	112.70	511.00
	Non-Event	7.06	4.72	8.52
P2-1981	Total	239.00	4755.85	4982.76
	Event	45.30	4044.00	4723.00
	Non-Event	193.70	711.85	259.76
P3-1980	Total	10.68	55.39	63.42
	Event	1.48	2.14	33.50
	Non-Event	9.20	53.25	29.92

*May-September

The difference in tonnage can be related to the surface cover management practices, there is little or no soil cover during June due to planting activities; in March the residue left after corn harvest protects the soil thus keeping available source areas of sediment to a minimum. Most annual losses of sediment and associated nutrients occurs in the two months following corn planting when the clean-tilled soil surface was susceptible to erosion according Burwell (1975). Table 45 indicates that the Blue Creek Watershed exhibits a similar trend.

January, 1981 and September, 1981 show a similar trend; precipitation in January occurred as snowfall on frozen ground, whereas precipitation during September was caused by a frontal system (low intensity) passing thru the area on the 1st. In January, 1981 there was no measured transport of material while during September almost 4 tons was transported by Station B (Table 45), the surface cover that was established or residue left minimized raindrop impact on the soil surface.

Sediment Delivery Ratio

In 1979, a lake sediment survey was conducted for Pittsfield City Lake (Bogner, 1979), where the average annual sediment deposition in the lake for the past 18.3 years (1961-1979) was found to be 38,576. From 1962-1974 annual sediment deposition was estimated to be 39,266 tons while from 1974-1979; 22,635 tons were deposited annually (Bogner, 1979). The Brune reservoir trap efficiency coefficient (1953) is estimated to be 93 percent. The annual sediment yield of the watershed from 1974 to 1979 would be 24,339 tons (22,635/0.93). The delivery ratio is defined as the ratio of sediment yield to the amount of gross erosion. In the Blue Creek Watershed, total gross erosion is estimated to be 63,313 tons (Davenport, 1982c). The sediment delivery ratio during the 1974 to 1979 period is 38 percent. The sediment delivery ratio for the watershed from 1961-1979 is estimated to be 66 percent (Davenport, 1982B).

The results of the 1979 and 1974 surveys indicate that there is a decrease in the sedimentation rate from 1.24% per year from 1961 to 1974 to 0.64% from 1974 to 1979. The overall sedimentation rate 1961-1979 was 1.08% (Bogner, 1979). The median storage depletion for all U.S. reservoirs is 1.5% per year (McDowell, 1976).

Changes in the sediment delivery ratio are likely, due to changes in the sediment source areas. A substantial reduction in the amount of sediment delivered to a stream may result in a compensatory increase in channel erosion produces sediment that is immediately available to the transport system. Whereas sediment from cropland must first get to the stream before it can be transported (Davenport, 1982B). There has been a substantial change in agricultural management on the watershed since the reservoir was constructed in 1961; the switch from pasture (grasses) to row crop is the dominant change. The ACP Special is being targeted toward treating this row crop land. Reduction in soil erosion does not always produce visible improvements in water quality since silt and clay particles are the hardest to control and yet contribute the most to water color and turbidity. Knox, (1977) concluded that land use not only exerts a strong contemporary influence on associated rates of surface runoff and sediment yields, but it may indirectly affect watershed processes and sediment yields of subsequent periods as channel systems attempt to reestablish an equilibrium with new watershed conditions. The improved land use or watershed conservation practices results in erosion of sedimentary deposits that accumulated during preceding periods of high yields (Trimble, 1976; Happ, 1940), this a version of the exhaustion effect illustrated earlier.

Sub-Basin Water Quality

Station D is located on the western side of Pittsfield City Lake. This is the only sub-basin station within the watershed being monitored and it is sampled on an event-runoff basis. Total suspended solids, volatile suspended solids, total kjeldahl nitrogen, total phosphorus and chemical oxygen demand are the only parameters measured at this site. Due to mechanical problems Station D's sampling has been limited to six events. For water quality parameter significance please refer to the proper subsection of the Stream Water Quality Section.

Suspended Material

Suspended material is composed of total suspended solids (TSS), volatile suspended solids (TVS) and non-volatile solids (NVS). The mean TSS concentration during Water Year 1981 was 3059.4 mg/l, while mean TVS concentration was 228.6 mg/l (Table 48). These higher than those recorded at any of the stream stations (Tables 13 and 15). TSS and TVS concentrations exhibited a distinct seasonal pattern, P1's values are higher than P2's. This seasonal trend results from the interrelationship between surface cover and the precipitation pattern. Large quantities of suspended material has settled out before it reaches the gauging site.

Total Kjeldahl Nitrogen (TKN)

Analysis for TKN measures both ammonia (NH3) and organic nitrogen. Station D's mean TKN concentration during Water Year 1981 was 6.8 mg/l, (Table 48) which is higher than those recorded at the Stream Stations A and B, but lower than Station C's (Table 20). TKN concentrations were higher during P1 than P2.

TABLE 48

Means and standard deviations of the parameters measured at Station D, expressed in mg/l, by analysis period.

	Parameters				
	TSS	TVS	TKN	COD	PTL
Water Year 1981 ($\bar{X}$)	3059.4	228.6	6.8	142.5	2.6
Standard Deviation	2303.4	159.4	2.2	48.8	1.0
Sample Size	13	13	11	11	8
P1 -- 1981 ($\bar{X}$)	3795.0	281.6	7.2	151.0	2.8
Standard Deviation	211.9	142.5	1.8	41.9	0.9
Sample Size	10	10	10	10	7
P2 -- 1981 ($\bar{X}$)	857.0	67.8	5.0	104.0	1.8
Standard Deviation	395.4	22.9	2.2	49.1	0.5
Sample Size	5	5	3	3	3

Organic Matter Demand

Chemical oxygen demand (COD) values range from 57.0 mg/l to 230.0 mg/l. COD exhibited a definite seasonal trend with higher values during P1 than P2.

Total Phosphorus (PTL)

PTL concentrations ranged from 1.2 mg/l to 4.3 mg/l. All PTL samples collected at Station D exceeded the general use standard of 0.05 mg/l set by the Illinois Pollution Control Board and the USEPA recommended value.

PTL concentrations exhibited a definite seasonal trend with higher values during P1 than P2. This results from combination of more PTL being available for transport and PTL being transported on sediment. TSS decreased significantly from P1 to P2 thus reducing PTL transported in the particulate form.

Field Site Monitoring

There are three field sites in the Blue Creek Watershed. These sites are sampled only on event-runoff basis. Runoff from cropland is monitored at Stations E and F. At Station J runoff from a vegetative filter strip is sampled. The same parameters are sampled at the field sites as at sub-basin Station D. For water quality significance, please refer to the proper subsection of the Stream Water Quality Station.

Status of Agricultural Activities on the Field Sites

Site E; canopy cover during Water Year 1981 is shown below. The wheat crop was planted first part of November, harvested first part of July.

Month	Percent cover	
April	75	canopy cover
May	95	
June	95	
July	85	harvest, residue cover
August	80	
September	80	
October	80	

Site F; crop varied by field. Field 3 was in pasture, field 4 was in soybeans and fields 2 and 5 were in corn. The only rainfall runoff event sampled at Site F occurred in October. Fields 2 and 5 had a canopy cover of 95%, field 4 had a residue cover of 60% and field 3 had ground cover of 95%.

Site J; the feed lot contained approximately 200 hogs throughout Phase II.

TABLE 49

Mean and standard deviations of parameters measured at Station E by analysis period, expressed in milligrams per liter.

	TSS	TVS	TKN	COD	PTL
Water Year 1981 ($\bar{X}$)	3561.5	188.1	5.37	107.74	1.48
standard deviation	6234.8	329.9	3.60	75.49	0.68
sample size	33	33	27	27	27
P1-1981 ($\bar{X}$)	4346.3	228.8	5.37	107.74	1.48
standard deviation	6657.7	352.8	3.60	75.49	0.68
sample size	27	27	27	27	27
P2-1981 ($\bar{X}$)	34.4	7.9	3.23	78.67	2.90
standard deviation	12.7	5.0	0.06	4.73	0.26
sample size	9	9	3	3	3

TABLE 50

Mean and standard deviations of parameters measured at Stations F and J for analysis period (P2), expressed in milligrams per liter.

	TSS	TVS	TKN	COD	PTL
Station F ($\bar{X}$)	344.5	28.7	3.18	74.00	1.40
standard deviation	109.4	6.7	0.76	24.66	0.21
sample size	11	11	4	4	3
Station J ($\bar{X}$)	383.8	29.7	3.11	68.00	3.50
standard deviation	196.7	12.8	1.29	34.35	0.99
sample size	9	9	9	9	9

Suspended Material

Suspended materials (TSS) is of both organic (TVS) and inorganic (NVS) particulate matter. Tables 49 and 50 shows the extreme variation in TSS concentrations between stations.

Stations F and J mean TSS concentration were approximately 10 times higher than Station E's during P2-1981, this is related to the ground cover differences. Station E's mean TSS and TVS concentration were higher than those determined for Station D.

Station E's mean TSS and TVS concentrations significantly decreased (99%) from P1 to P2. This agrees with Burwell (1975) findings, that most annual losses of sediment occurred in the two months following planting when the soil surface was most susceptible to erosion. The concentrations measured during P1 resulted from the November planting activities and were moved only with sufficient overland flow.

Total Kjeldahl Nitrogen (TKN)

Analysis for TKN measures both ammonia (NH3) and organic nitrogen. Mean TKN concentrations at all stations are approximately equal during P2. Mean TKN concentration significantly decreases from P1 to P2 at Station E. Schuman (1973) suggests this seasonal effect is related to progressive N removal by crop use, leaching, N tie-up in organic matter, and overland movement. Liquid N was applied at the rate of 80 lbs/acre in the spring. The field stations' mean TKN concentrations were less than those measured at the sub-basins station.

Organic Matter Demand (COD)

Mean COD values during P2 were approximately equal. Mean COD values significantly decrease from P1 to P2 at Station E. All three field stations' mean COD values are lower than the sub-basin station.

Total Phosphorus (PTL)

All PTL concentrations determined for the field stations exceeded the Illinois general use standard. Mean PTL concentration at Station J was higher than that measured at Station's E and F. The higher value for Station J is because its drainage encompasses hog feedlot McCarty (1967) documented that animal excrement is a source of P to surface water. The mean PTL concentration at Field Station J is lower than the sub-basin stations.

Mean PTL concentrations increased from P1 to P2 at Station E. Leaching of the residue and greater selectivity of the soil erosion process during P2 probably causes the increase. Fall fertilization of 100 lbs/acre of P_2O_5 and KCl occurred in November.

Effectiveness of Land Treatment on the Field Sites

On October, 1981 a rainfall-runoff event was measured at all three field stations. Refer to the Status of Agricultural Activities on the Field Sites subsection on page 87 to determine the condition of the individual field site during the October 5, 1981 storm event. Total precipitation basin-wide 1.52 inches, at rain gauge closest to Station J 1.20 inches was measured and at rain gauge closest to Stations E and F 1.82 inches was measured (Figures 2 and 3).

Erosion on feedlots averaged 36 tons/acre/year in the Blue Creek Watershed (Davenport, 1982A). The vegetative filter strip has reduced the potential pollution level of a feedlot so it is equivalent to that of Field Station F for all parameters except PTL. Station F is a 78-acre drainage area consisting of four fields under various management conditions whose average annual soil erosion is less than 5.0 tons/acre. Which is the ultimate goal of the State Soil Erosion and Sediment Control Program (1979). TSS and TVS concentration in the runoff from Station J were greater than Station E. This mainly the result of the variation in the surface cover, Station E's drainage has an average of 80% whereas Station J's is 50% baren. There was not a significant difference in PTL, COD and TKN concentrations between the two stations.

Station F had higher TSS and TVS concentrations in comparison to Station E. Station E had higher PTL concentrations. The higher PTL concentrations result from surface cover differences and the leaching of the residue on Station E's drainage. There was not a significnt difference in COD and TKN concentrations between the two stations.

Lake

Pittsfield City Lake is a 218-acre impoundment that was constructed in 1961 as a multiple purpose reservoir. It is utilized as a public water supply and for recreation by the surrounding area. The lake has a maximum depth of 32 feet and a mean depth of 12 feet. The watershed area/lake capacity ratio is 2.5, while the mean hydraulic retention time is 0.554 years (Table 51). Pittsfield City Lake is classified as an artificial central lake due to its geographic location and being man-made.

TABLE 51

Location, physical description and morphometry of Pittsfield City Lake, Pike County, Illinois.

Lake*

Latitude	39o 37' 51"
Longitude	90o 44' 46"
Basin	Illinois River
Segment	B-06
Normal pool elevation	596 ft.
Maximum length	1.5 mi.
Surface acres	218
Maximum depth	32 ft.
Length of shoreline	5.20 miles
Bottom slope	0.3617
Storage volume	2,773 acre-feet
Retention time	0.554 year
Annual capacity loss	1.08%
Total original capacity loss	19.7%

Watershed*

Major tributary	Blue Creek
Drainage area	11.1 mi2 (7,028 acres)
Area excluding lake	10.6 mi2 (6,810 acres)
Average annual soil loss	26.7 tons per acre

*IEPA, 1980

The water quality and use characteristics of Pittsfield City Lake are being monitored to determine the impacts of RMS's implementation within the watershed upon water quality. The monitoring effort of the lake consists of two components: 1) an evaluation of the Pittsfield City Water Treatment Plant's records and 2) an intensive 4 year monitoring program in the lake. Pittsfield City Lake was sampled in 1979, 1980 and 1981, the data has been summarized in Tables 52 and 53. Water quality data, dating back to 1965 was available from the Pittsfield City Water Treatment Plant.

Turbidity at the Water Treatment Plant

Turbidity is the term used to describe the degree of opaqueness produced in water by suspended particulate matter. The kinds of materials creating turbid conditions in a given body of water are as varied as the biotic and abiotic composition of the surrounding terrain, inflowing streams, and the lake itself. Silt, clay, particulate organic and inorganic matter, plankton and other microorganism may all contribute substantially to the quantity and proportions of particulate matter available. The nature of materials causing turbidity is important, because of its physical properties, potential chemical interactions, and total loads. Turbidity is not a uniform parameter since the quantity and quality of suspended particulate matter is so variable in nature (Reid, 1961).

Turbidity has been measured at the Pittsfield Water Treatment Plant since June, 1976. The results are expressed in NTU's (Nephelometric Turbidity Units) which are based on standards prepared from a formazin polymer (APHA, 1980).

Figure 7 indicates that mean monthly turbidity in water taken from Pittsfield City Lake has been increasing. Close inspection of the data reveals, as expected, a general trend of lower turbidity levels during December, January and February. Historically, these months have low levels of precipitation usually only 13% of the long term annual. Whereas, peak concentrations are expected during April and May due to the normal precipitation and land management patterns within the watershed. Land management activities during April and May are usually related to planting and seedbed establishment which cause soil disturbance and thus expand potential source areas for suspended solids.

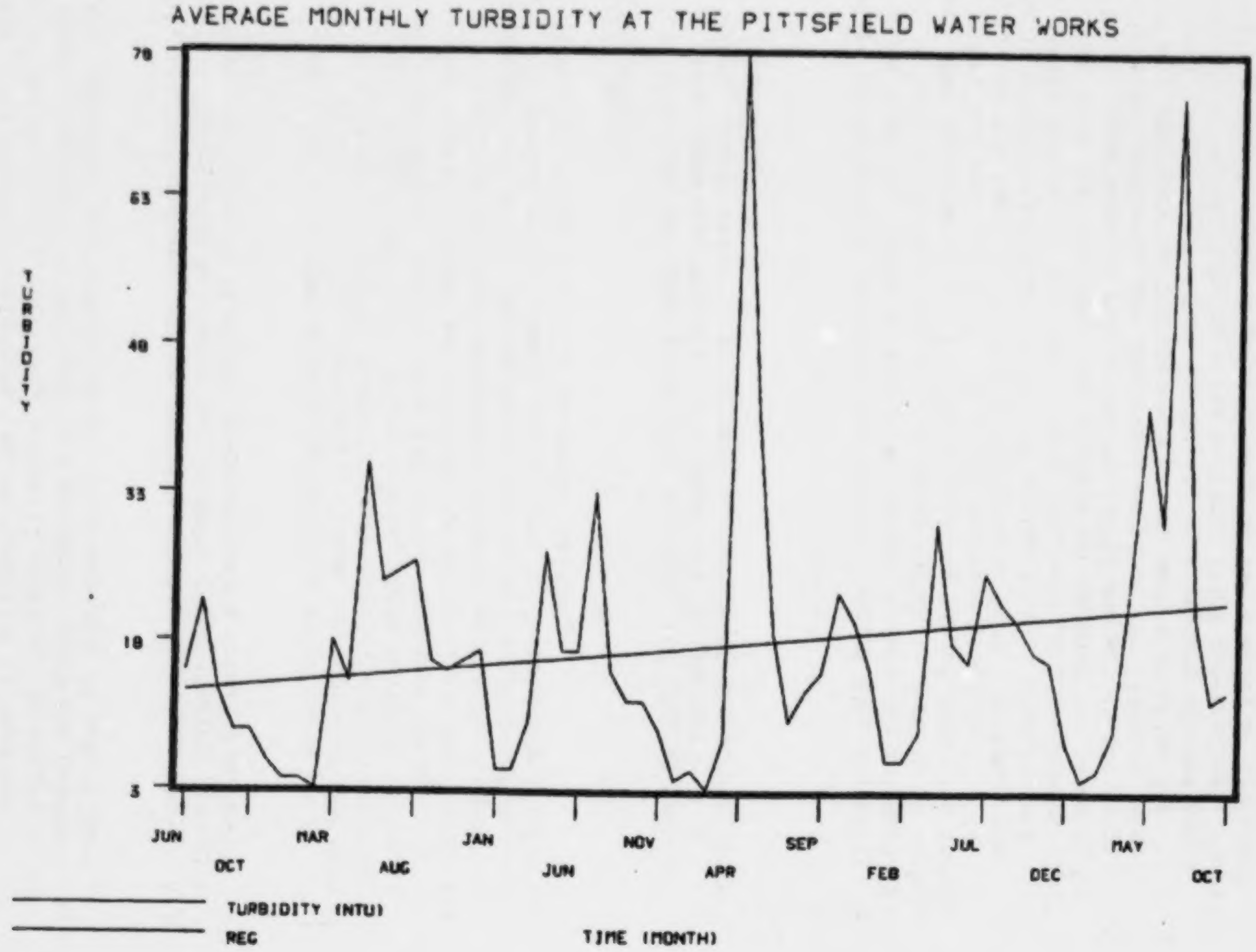
LAKE WATER QUALITY

Pittsfield City Lake was sampled in 1979 and 1980, and 1981 as part of the Blue Creek Watershed Project. For water quality parameter significance, please refer to the proper subsection of the stream water quality subsection.

Secchi

The waters of Pittsfield City Lake are turbid. Secchi disc visibility in 1979 ranged from six inches in May to 40 inches in June and averaged 19 inches; in 1980 visibility ranged from seven inches to June to 45 inches in August and averaged 24.6. In 1981 visibility ranged from nine inches to 24 inches and averaged 17.7. This 29% decrease in visibility is caused by the 41% increase in precipitation over 1980. Although the average is within reasonable limits the variability of transparency depths limits utility of the lake. This 1981 average transparency (17.7 inches) was less than the four feet minimum recommended for swimming by the Illinois Department of Public Health (1976) and was in the range generally associated with use impairment problems for Illinois lakes. The 1979 and 1980 average transparency values were also below the recommended level. Secchi disk visibility is a measure of lake water transparency or its ability to allow vertical light penetration. Secchi disc transparency provides a general index of the clarity of the water and its physical and optical properties, including water color, turbidity, dissolved and suspended organic and inorganic material. The depth of water capable of photosynthesis is called the euphotic zone. This zone generally determines the maximum depth for biological life requiring oxygen to survive and, therefore, limits available habitat and diversity. The one percent light penetration depth is generally defined as the lower limit of the euphotic zone (IEPA, 1980).

FIGURE 7



June 1976 to October 1981

In assessing the results of the National Eutrophication Survey, Allum et. al. (1977) classified oligotrophic lakes as those with Secchi depths in excess of 3.7 meters (12.1 feet). Mesotrophic lakes had Secchi depths between 2.0 and 3.7 meters (6.6 and 12.1 feet), while those with Secchi transparency of less than 2.0 meters (6.6 feet) were eutrophic (Sefton, 1978).

Based on the above classification, Pittsfield would be considered eutrophic (mean Secchi transparency of less than 2 feet). In comparison with 87 lakes monitored during 1981, Lake Pittsfield would be in the lower 22%. The average for the 87 lakes was 39.1 inches, while Lake Pittsfield averaged 17.7 inches (IEPA, 1982). A spatial trend in Secchi was found, with the least transparency generally recorded at the headwaters site with increased values down -- lake. Temporally, Secchi disk visibility measured after periods of rainfall was the least; greatest measurements were recorded after periods of no precipitation. Complete Secchi disk data is presented in the Appendix Section.

Secchi disk visibility increased from P1 to P2. This increase in visibility results from lower surface water suspended solid concentrations during crop maturation and growth.

Turbidity

The mean turbidity in surface waters of Pittsfield City Lake was 14.1 NTUs in 1981 (22.0 NTUs-1979 and 7.3 NTUs-1980). The mean bottom water turbidity was 35.9 NTUs (1979-36.5 NTUs, 1980-9.6 NTVS). 1981 was 17% above the normal in terms of precipitation, 1980 was 24% below normal in terms of precipitation (Refer to Table 9) while 1979 was 5.29 below normal.

Minimum values for the turbidity in-lake water samples were recorded in August, except at site 2, where the minimum turbidity was observed in September. Highest turbidity values were observed in June. This pattern correlates with the land management activities being carried out in the watershed and the precipitation. Periods of low turbidity correspond to the period when the agricultural canopy cover was nearly 100%. Complete turbidity data is presented in the Appendix Section.

Suspended Solids

Concentrations of total (TSS) and volatile suspended solids (TVS) in Pittsfield City Lake are presented in the Appendix Section. Mean surface values for samples taken during 1981 were 42.0 and 7.4 mg/l for TSS and TVS respectively. In 1979 and 1980 mean TSS concentrations were 41.1 and 38.6 mg/l respectively. On the average in 1981, TVS comprised 17% of TSS. In surface water samples the percentage of TVS comprised by TVS ranged from 21 to 24%, whereas at both bottom water sites TVS comprised 20% of TSS. This indicates the suspended solids were probably inorganic in nature. Inorganic suspended soils in many Illinois lakes result largely from soil erosion and the subsequent runoff of soil particles into reservoir tributaries (Sefton, et. al., 1980). Maximum observed values for TSS and TVS were 110.0 mg/l and 22.0 mg/l, while minimum values were 22.0 mg/l and 4.1, respectively. Maximum and minimum values for both TSS and TVS were lower in 1980 and 1979. The "upstream -- downstream" difference in TSS and TVS that was exhibited during 1979 and 1980, was present during 1981.

This could result from resuspension of bottom material and from sub-watershed contributions down lake of Lake Site 2. Data from Station D (Figure 2) indicates that the sub-watershed around the lake contributing significant quantities of suspended material. Station D's mean TSS concentration during Water Year 1981 was 3059.4 mg/l while the lake inflow Station B's average was 200.6 mg/l.

Seasonally surface TSS and TVS values decreased between P1 and P2. This probably results from canopy establishment during P2 and the decrease in potential source areas.

Nitrate-Nitrite (N32)

N32 values show a definite "upstream-downstream" difference. Site 3, at the headwaters, had much higher values than sites 2 and 3. N32 concentrations did not exceed the Illinois Pollution Control Boards' (1977) limit of 10 mg/l and 1 mg/l respectively.

N32 concentrations decreased from P1 to P2 at all lake sites. This decrease can be attributed to uptake by algae throughout summer, decrease in land inputs, and dilution. Mean surface water concentrations (0.39 mg/l) shows extreme variation from mean bottom water concentrations (0.96 mg/l). There is considerable variation between 1979, 1980 and 1981 values, no trends are easily definable. Complete N32 data is presented in the Appendix Section.

Total Ammonia Nitrogen (NH3)

The Illinois Pollution Control Board (1977) specivied that NH3 should not exceed 1.5 mg/l for general use waters. NH3 concentrations in Pittsfield City Lake ranged from 0.0 to 2.10 mg/l, with site 1 bottom samples having the highest mean concentrations (X = 0.78) and at bottom site 1 the water is anoxic water due to its depth and thermal stratification. Mean NH3 concentrations in the surface waters were between 0.02 and 1.20 mg/l; highest surface water concentration occurred in September. All values exceeds the 0.02 mg/l limit USEPA recommended for the protection of aquatic life.

Total Kjeldahl Nitrogen (TKN)

Values for TKN include both NH3-N and organic nitrogen (N). TKN minus NH3-N is equivalent to the organic N level.

Mean TKN concentrations for all Pittsfield City Lake sites were between 0.81 and 2.63 mg/l. Concentrations ranged from 0.9 to 4.20 mg/l, with highest values always being observed in the bottom water samples.

Total Phosphorus (PTL)

The Illinois Pollution Control Board (1977) general use standard for PTL is 0.05 mg/l. In assessing the 1973 National Eutrophication Survey results Allum et. al., (1977) classified oligotrophic lakes as those with PTL values below 0.01 mg/l and mesotrophic as those with PTL values between 0.01 and 0.02 mg/l. Eutrophic lakes had PTL values greater than 0.02 mg/l (Sefton, 1978).

Based on the above classifications, Pittsfield City Lake would be considered eutrophic ($X = 0.14$ mg/l). This classification corresponds to that based on secchi transparency. The minimum PTL concentration was 0.06 mg/l which exceeds the 0.05 mg/l standard.

The bottom sample values ranged from 0.06 and 0.61 mg/l, respectively. The high PTL in the bottom water at site 1 can be expected because of the existance of anoxic conditions (Stumm, 1970) and the release P from particulate matter settling from the epilimnion.

Dissolved Phosphorus (DSP)

Mean dissolved phosphorus (DSP) was higher in the bottom water of site 1 than at any other sample site. In surface water, the DP comprised approximately 16% of the TP, this is a decrease of 25% over 1981. In bottom water, DSP comprised 45% and 43% of PTL at sites 1 and 2, respectively. The percentage of PTL that is dissolved in bottom water in 1981 is slightly higher than in 1980 and 1979.

The increased DSP percentage of TP could result from the implementation of conservation tillage systems (Table 6). Barasis (1978) attributes high DSP losses from conservation tillage systems to a lack of incorporation of broadcast P fertilizers and he also suggest that leaching of plant tissue may be an additional source. Conservation tillage reduces PTL concentrations due to controlling particulate matter transport from the field (Mueller, 1981). DSP does not decrease proportionally, so the ratio increases.

Dissolved to Total Phosphorus Ratio

Consideration of the dissolved to total phosphorus (i.e., DSP/PTL) can be informative when evaluated with respect to total or dissolved phosphorus concentrations. A high DSP/PTL indicates, of course, that most of phosphorus present is in the dissolved state. Such a condition would imply high DSP input rates and/or relatively low primary production rates (Sefton, 1980).

The mean DSP/PTL ratio in Pittsfield City Lake surface water ranged from 0.07 at Site 1 on September 10th to 0.39 at Site 2 on June 6th. The mean during Water Year 1981 was 0.16. The mean bottom water DSP/PTL ratio ranged from 0.23 to 0.76; the mean was 0.42. Bottom water ratio tended to be higher than their surface water counterparts. The higher ratios encountered in bottom waters presumably are attributable to increase in the dissolved fraction as a result of the lower redox potentials associated with the bottom waters and release by bottom sediments.

Total Nitrogen to Total Phosphorus Ratio

Since the ratio of nitrogen to phosphous in plant materials is generally conceded to be in the neighborhood of 7:1 (Round 1966, Serruya, et al. 1974, Wetzel 1975), consideration of the total nitrogen to total phosphorus ratio (i.e., TKN/PTL) can be informative when evaluated with respect to TKN and PTL concentrations. TKN/PTL ratios above 7:1 indicate that the amount of phosphorus present is limiting to the utilization of all the nitrogen available for algal and aquatic macrophyte production while ratios below 7:1 indicate that nitrogen is limiting utilization of all the phosphorus available (Sefton, 1980).

The mean TKN/PTL ratio in Pittsfield City Lake surface waters ranged from 7.42 to 18.41; the mean was 12.30 in bottom waters the mean TKN/PTL ratio ranged from 12.2 to 17.1; the mean was 15.52. This indicates that the amount of PTL present limited the utilization of all the nitrogen present.

Inorganic Nitrogen to Dissolved Phosphorus Ratio

Consideration of the inorganic nitrogen to dissolved phosphorus ratio (i.e., IN/DSP) in the water can be informative when evaluated with respect to IN and DSP concentrations. When the IN/DSP ratio is less than 15:1, nitrogen is probably the limiting nutrient (i.e., limits utilization of all the phosphorus available); when it exceeds 15:1, the limiting nutrient is probably phosphorus (USEPA, 1980).

The mean IN/DSP ratio in Pittsfield City Lake surface waters ranged from 5.0 to 34.28; the mean ratio was 16.37. In bottom waters the mean IN/DSP ratio ranged from 15.73 to 26.78, the mean ratio was 21.31. This indicates that phosphorus is the limiting nutrient and it is an agreement with the TKN/PTL ratio.

Conductivity

A measure of the total amount of ionized material in water can be obtained by determining its electrical conductance. Pure water has a very low electrical conductance. However, the presence of charged particles (ions) in solution makes the solution conductive (IEPA, 1980).

Conductivity data for Pittsfield City Lake are presented in the Appendix Section. Surface conductivity varied from 84 to 305 umhos/cm and averaged 255 umhos/cm in Pittsfield City Lake during 1981. Bottom conductivity ranged from 257 to 380 umhos/cm, with a mean value of 307 umhos/cm. The 1981 maximum and mean values for both surface and bottom water were below the 1979 and 1980 values.

Chloride (Cl)

The major influence of Cl in aquatic systems is exerted by its contribution to salinity thus affecting the overall habitability of the environment by virtue of its effect on the osmorequaltory ability of aquatic organisms. The Illinois Pollution Control Board (1977) has set the general water quality standards for state water such that Cl concentration shall not exceed 500 mg/l. Cl concentrations in Pittsfield City Lake were only measured on one occasion (Table 33).

Fecal Coliform (FC)

The Illinois Pollution Control Board (1977) has determined that FC levels below 200/100 ml of water sample should be adequate to protect the 'States' water for aquatic life, agricultural use, primary and secondary contact use (IEPA, 1980). The FC value for Pittsfield City Lake were (23/100 ml) in 1981, Site 3 (20/100 ml) and 2 (30/100 ml).

Alkalinity

Alkalinity is a measure of water's capacity to neutralize an acid. It indicates the presence of carbonates, biocarbonates, and hydroxides, and less significantly, borates, silicates, phosphates, and organic substances (McNelly et. al., 1979). Alkalinity in lakes is primarily governed by the geochemistry of the watershed, and is expressed as an equivalent of calcium carbonate ($CaCO3$). The Illinois Pollution Control Board has not stipulated a standard for alkalinity in natural waters (IEPA, 1980).

Total alkalinity concentrations in surface water samples from Pittsfield City Lake ranged from 100.0 to 138.0 mg/l $CaCO3$, with a mean value of 121.4 mg/l $CaCO3$. The bottom water alkalinity values ranged from 99.0 to 156.0 mg/l $CaCO3$, with a mean value of 123.2 mg/l $CaCO3$. Groundwater flow may have raised the alkalinity of the bottom to higher levels.

Chemical Oxygen Demand

Chemical Oxygen Demand (COD) was not sampled in 1979. 1980 COD values exhibited a definite 'upstream-downstream' pattern, site 3 (42 mg/l) highest and site 1 (20 mg/l) lowest. COD values in surface water ranged from 15 to 164 mg/l and averaged 28 mg/l. Bottom water COD values averaged 25 mg/l and ranged from 15 to 55 mg/l (Table 33).

1981 COD values exhibited the same 'upstream-downstream'pattern that the 1980 data, site 3 (35 mg/l) highest and site 1 (23 mg/l) lowest. COD values in surface water ranged from 16 to 74 mg/l. Bottom water COD values averaged 23 mg/l and ranged from 18 to 35 mg/l (Table 33). Bottom values COD value between sites 1 and 2 were approximately equal.

Lake inflow, Station B, COD values averaged 41 mg/l and at Lake Site 3 averaged 35 mg/l (Figure 2). The COD values at site 1 (23.0 mg/l) and Station A (23 mg/l) are equivalent during 1981.

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TABLE 52

Summary of select water quality parameters in surface water samples from Pittsfield City Lake; 1979, 1980 and 1981.

		1979	1980	1981
DSP ($\bar{X}$) (mg/l)	(X)	0.03	0.03	0.03
	SD	0.02	0.02	0.02
	Max	0.07	0.07	0.05
	Min	0.00	0.01	0.00
Turb ($\bar{X}$) (NTU's)		22.00	7.28	14.10
	SD	17.77	10.23	19.91
	Max	50.00	44.00	90.00
	Min	7.10	1.00	3.00
TSS ($\bar{X}$) (mg/l)		26.39	16.40	25.17
	SD	14.20	12.02	22.30
	Max	52.00	60.00	106.00
	Min	10.00	5.00	9.00
TVS ($\bar{X}$) (mg/l)		5.50	3.76	6.67
	SD	2.12	3.08	4.14
	Max	9.00	13.00	22.00
	Min	2.00	0.00	3.00
Temp ($\bar{X}$) (°C)		*	20.98	22.55
	SD		9.98	4.76
	Max		31.90	27.90
	Min		3.00	15.30
DO ($\bar{X}$) (mg/l)		6.41	8.19	12.05
	SD	1.19	2.42	3.78
	Max	8.0	13.90	18.70
	Min	4.10	5.30	5.60
COD ($\bar{X}$) (mg/l)		*	28.10	28.22
	SD		31.68	14.02
	Max		164.00	74.00
	Min		15.00	16.00

		1979	1980	1981
COND ($\bar{X}$) (umhos/cm)		299.33	279.20	255.80
	SD	31.22	66.71	41.17
	Max	405.00	328.00	305.00
	Min	251.00	125.00	184.00
T-ALK ($\bar{X}$) (mg/l)		104.70	121.38	121.43
	SD	18.10	34.17	11.93
	Max	133.00	146.00	138.00
	Min	70.00	0.00	100.00
Secchi ($\bar{X}$) (inches)		18.8	24.5	17.7
	SD	9.5	10.6	4.2
	Max	40.0	45.0	24.0
	Min	6.0	7.0	9.0
N32 (X) (mg/l)		0.46	0.18	0.14
	SD	0.52	0.13	0.18
	Max	1.40	0.30	0.78
	Min	0.01	0.00	0.01
NH3-N ($\bar{X}$) (mg/l)		0.08	0.10	0.14
	SD	0.09	0.15	0.28
	Max	0.29	0.70	1.20
	Min	0.01	0.00	0.10
TKN ($\bar{X}$) (mg/l)	0.96	0.86	1.30	
	SD	0.19	0.23	0.47
	Max	1.40	1.40	2.60
	Min	0.70	0.50	0.90
PTL($\bar{X}$) (mg/l)		0.10	0.08	0.13
	SD	0.04	0.04	0.07
	Max	0.22	0.19	0.36
	Min	0.05	0.04	0.04
Fecal ($\bar{X}$) # organisms/100 ml		*	117.14	23.33
	SD		237.99	5.77
	Max		900.00	30.00
	Min		10.00	20.00

TABLE 53

Summary of select water quality parameters in bottom water samples from Pittsfield City Lake; 1979, 1980 and 1981.

		1979	1980	1981
DS ($\bar{X}$)		0.05	0.08	0.07
(mg/l)	SD	0.04	0.08	0.07
	Max	0.18	0.27	0.23
	Min	0.01	0.01	0.02
Turb ($\bar{X}$)		22.00	9.60	35.88
(NTU's)	SD	11.66	7.69	31.56
	Max	50.00	26.00	120.00
	Min	7.10	2.00	5.40
TSS ($\bar{X}$)		41.08	38.58	42.00
(mg/l)	SD	26.94	20.25	29.96
	Max	121.00	92.00	110.00
	Min	13.00	12.00	10.00
TVS ($\bar{X}$)		6.83	7.75	7.42
(mg/l)	SD	3.79	5.87	5.74
	Max	17.00	23.00	21.00
	Min	3.00	2.00	1.00
PTL (X)		0.17	0.24	0.22
(mg/l)	SD	0.12	0.21	0.16
	Max	0.48	0.66	0.61
	Min	0.06	0.04	0.06
PTL ($\bar{X}$)		0.42	0.17	0.36
(mg/l)	SD	0.52	0.15	0.57
	Max	1.40	0.39	1.70
	Min	0.01	0.00	0.01
NH3-N ($\bar{X}$)		0.53	1.04	0.55
(mg/l)	SD	0.59	1.34	0.70
	Max	2.00	3.87	2.10
	Min	0.04	0.01	0.00

		1979	1980	1981
TKN ($\bar{X}$) (mg/l)		1.36	1.82	1.66
	SD	0.67	1.55	0.98
	Max	2.80	4.50	4.20
	Min	0.70	0.50	0.90
Temp ($\bar{X}$) (°C)			16.43	14.99
	SD	*	8.47	4.47
	Max		31.00	21.80
	Min		3.00	8.10
DO ($\bar{X}$) (mg/l)			5.83	1.76
	SD	*	5.21	2.49
	Max		13.90	6.50
	Min		0.00	0.00
COND ($\bar{X}$) (umhos/cm)		322.62	322.93	307.10
	SD	95.91	58.05	32.83
	Max	620.00	440.00	380.00
	Min	260.00	191.00	257.00
T-ALK ($\bar{X}$) (mg/)		109.00	159.70	123.20
	SD	31.67	37.08	18.30
	Max	150.00	200.00	156.00
	Min	60.00	100.00	99.00

LAKE CLASSIFICATION

A wide range of physical, chemical, and biotic parameters have been used to describe freshwater lakes and the multitude of descriptive indices and lake classification systems which have evolved have been summarized by Uttormark and Wall 1975; Sefton 1978a; and Van Benschoten 1978. Lakes have been historically classified by nature of geologic origin and more recently on the basis of productivity or trophic status. Traditionally, lakes classified by trophic status have been placed into three broad categories (from Sefton 1978a):

1. Oligotrophic lakes have low concentrations of nutrients such as phosphorus and nitrogen and support little plant growth. Biolgical productivity is generally low, and the waters are clear (Naumann 1919, 1931; Hasler 1947; Hasler and Ingersoll 1968, Vollenweider 1968).

2. Mesotrophic lakes are intermediate in character between oligotrophic and eutrophic. They are moderately well supplied with nutrients and generally support moderate biological productivity.

3. Eutrophic lakes are nutrient rich and generally higly productive, capable of supporting a large amount of plant growth and other biological activity (Naumann 1919; Hasler 1947; Hasler and Ingersoll 1968; Vollenweider (1968). Eutrophic lakes cover a myriad of water quality conditions, ranging from very desirable recreational lakes that support excellent warmwater fisheries to lakes with undesirable aeshetics and water use limitations (Rogers 1977).

The eutrophication process is classically defined in terms of natural glacial lakes. Glaciated lakes normally begin as oligotrophic bodies of water with stable quality and long natural successional lives. Increases in productivity of their waters are generally brought about by increasing nutrient concentrations. Artificial impoundments, however, frequently inundate rich bottom land soils and normally begin their lives with a high productivity potential. High reservoir productivity is maintained by nutrients and organic materials leaching from bottom soils and runoff from disturbed watershed lands. Many Illinois reservoirs are thus nutrient rich and considered eutrophic soon after construction.

PTL

In assessing the 1973 National Eutrophication Survey, results Allum et. al. (1977) classified oligotrophic lakes as those with PTL values below 0.01 mg/l and mesotrophic as those with PTL values between 0.01 and 0.02 mg/l. Eutrophic lakes had PTL values greater than 0.02 mg/l (Sefton, 1978). Based upon the above classifications, Pittsfield City Lake would be considered eutrophic (X = 0.22 mg/l).

Secchi

In assessing the results of the National Eutrophication Survey, Allum et. al. (1977) classified oligotrophic lakes as those with Secchi depths in excess of 3.7 meters (12.1 feet). Mesotrophic lakes had Secchi depths between 2.0 and 3.7 meters (6.6 and 12.1 feet), while those with Secchi transparency of less than 2.0 meters (6.6 feet) were eutrophic (Sefton 1978). Based on the above classification, Pittsfield would be considered eutrophic (Mean Secchi transparency of less than 2 ft.).

Trophic State Index

For purposes of possible trophic state comparison, trophic state index values were computed using equations developed by Carlson (1977). Carlson constructed his Trophic State Index (TSI) such that the zero point on the scale would denote a Secchi transparency depth (SD) greater than any yet encountered; the greatest known SD is 41.6 m for a lake in Japan. The formula was thus constructed so that TSI (SD) value of zero is obtained for a Secchi reading of 64 m; a value of 10 is obtained when SD=32, 20 for 16 m, 30 for 8 m and so forth. The theoretical limit is infinity; however, the practical limit of 100-110 is reached when transparency is from 0.064-0.032 m. Carlson also developed TSI formulae using total phosphorus and chlorophyll a data based on empirical relationships of these two parameters with SD, as follows:

$$\mathrm{TSI(SD)} = 60 - 14.41 \ln \mathrm{SD}$$

$$\mathrm{TSI(CHL\underline{a})} = 9.81 \ln \mathrm{CHL\underline{a}} + 30.6$$

$$\mathrm{TSI(PTL)} = 14.42 \ln \mathrm{TP} + 4.15$$

When considering the results of TSI calculations, one should keep in mind the assumptions on which the Carlson formulae are based: 1) Secchi transparency is a function of phytoplankton biomass; 2) phosphorus is the factor limiting algal growth; and 3) total phosphorus concentration is directly correlated with algal biomass (Sefton 1978a). These assumptions are a major source of turbidity, short retention times prohibit a large algal standing crop from developing, or grazing by zooplankton is affecting algal populations. Therefore, for Illinois lakes the TSI would better be considered an index of lake condition or quality rather than trophic state. The lower the TSI value the less eutrophic the lake.

TABLE 54

Trophic state indexes by parameter by year
for Pittsfield City Lake.

	1979	1980	1981
(TSI) Seechi Disk	70.6	68.4	72.0
(TSI) Total Phosphorus	75.9	65.7	72.3
(TSI) Chla	61.4	57.5	64.8
Mean TSI	69.3	63.9	69.7

According to Sefton (personal communication), lake water quality is often dependent upon rainfall. Rainfall on the Blue Creek Watershed was greater in 1979 and 1981 than 1980. The Lake showed improvement during 1980 when rainfall was 23.8% of normal.

List of Publications Pertaining to the Blue Creek Watershed Project

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APPENDIX SECTION

APPENDIX 1

List of Abbreviations and Symbols

USEPA = United States Environmental Protection Agency
SWCD = Soil and Water Conservation District
ASCS = Agricultural Stabilization and Conservation Service
SCS = Soil Conservation Service
ACP = Agricultural Conservation Program
IEPA = Illinois Environmental Protection Agency
PCB = polychlorinated biphenyls
ISWS = Illinois State Water Survey
"STORET" = storage and retrieval system
CES = Illinois Cooperative Extension Service
RMS = Resource Management System
NPS = nonpoint source
T = maximum allowable soil loss tolerance per acre
USLE = Universal Soil Loss Equation
C = Corn
Sb = Soybean
Gr = Wheat
in = inches
mm = millimeters
FC = Fecal Coliform
FS = Fecal Streptococcus
Ca = Calcium
Mg = Magnesium
Na = Sodium
TSS = Total suspended solids
TVS = Total volatile solids
NVS = Non-volatile solids
IPCB = Illinois Pollution Control Board
P = Period
NAS-NAE = National Academy of Science -- National Academy of Engineering
mg/l = milligrams per liter
NTU's = Nephelometric turbidity units
^{o}C = degrees centigrade
ms/cm = microsiemens per centimere
Ba = Batium
Be = Beryllum
Bo = Boron
Cd = Cadmium
Cr = Chromium
Co = Cobalt
Cu = Copper
Fe = Iron
Pb = Lead
Mn = Manganese
Ni = Nickel
Ag = Silver

St = Strontium
Vn = Vandadium
Zn = Zinc
Li = Lithium
Hg = Mercury
TKN = Total Kjeldahl Nitrogen
COD = Chemical Oxygen Demand
BOD = Biological Oxygen Demand
NH_3 = Ammonia
N32 = Nitrate & Nitrite
PTL = Total Phosphorous
DSP = Dissolved Phosphorous
KTL = Total Potassium
TEM = Temperature
CFS = Cubic feet per second

APPENDIX 2

Parameter -- sampling frequency for the Blue Creek Project's Water Quality Analysis.

PARAMETER/FREQUENCY	DAILY	WEEKLY	EVENT
Total Suspended Solids	X	X	X
Total Volatile Solids	X	X	X
Ammonia-Nitrogen		X	
Total Kjeldahl Nitrogen		X	X
Total Phosphorus		X	X
Nitrite & Nitrate		X	
Dissolved Phosphorus		X	
Biological Oxygen Demand		X	
Chemical Oxygen Demand		X	X
Iron		X	
Potassium		X	

APPENDIX 3

Parameters measured monthly (Organics, Meals & HG+2)

ICAP

- Barium
- Boron
- Cadium
- Copper
- Iron
- Lead
- Manganese
- Nickel
- Silver
- Zinc
- Beryllium
- Calcium
- Cobalt
- Lithium
- Magnesium
- Potassium
- Sodium
- Strontium
- Vanadium
- Mercury (Not ICAP)

ORGANICS

- Aldrin
- Chlordane
- DDT
- Endrin
- Heptachlor
- Heptachlor epoxide
- Lindane
- Methorychlor
- PCB's

APPENDIX 4

Blue Creek Project sampling schedule by frequency and location for chemical parameters.

FREQUENCY/SAMPLING LOCATIONS	A	B	C	D	E	F	LAKE SITES	COMMENTS
Daily		X	X					
Monday & Friday	X							
Weekly	X	X	X					Sample day is Wednesday.
Event	X	X	X	X	X	X		Station A is sampled twice daily 6 consecutive days after a storm.
Monthly Metals (ICAP)		X	X				X	
Monthly Organics		X	X				X	
Monthly							X	

APPENDIX 5

Summary of monitoring parameters. Sample preservation, methods of analysis, reporting units, and Geneal Use Standards as appropriate.

PARAMETER	SAMPLE CONTAINER	PRESERVATION	METHOD OF ANALYSIS (REFERENCE)	UNITS OF MEASUREMENT	DETECTION LIMITS	ANALYSIS	GENERAL USE STANDARD
Temperature			In sit determination using Yellow Springs Instruments (YSI) model 57 dissolved oxygen meter (1).	°C	nearest 0.1°	Field determination	
Dissolved Oxygen (DO)			In sit determination using YSI model 57 dissolved oxygen meter (1)	mg/1 O_2	0.1 mg/1	Field determination	no less than 5 mg/1
Transparency			Secchi disk (2).	feet	nearest 0.1 foot	Field determination	
Total Suspended Solids (TSS)	1/2 gallon polyethylene	refrigeration at 4°C	filtration on glass fiber filter, determination of increase in weight upon drying at 103-105°C(3, p. 268).	mg/1 TSS	1 mg/1	Regional IEPA lab	
Volatile Suspended Solids	1/2 gallon polyethylene	refrigeration at 4°C	Loss in weight of TSS filter upon ignition at 559°C (3, p. 2272).	mg/1 VSS	1 mg/1	Regional IEPA lab	
Turbidity	1/2 gallon polyethylene	refrigeration at 4°C	Mephelometrically using Hach model 2100A turbidimeter (3, p. 205).	NTU	0.05 NTU	Regional IEPA lab	
Conductivity			YSIU Model 33 S-C-T Conductivity meter or Electrolytic Conductivity Measuring Set, Model MC-1.	umhos/cm	nearest 1 umhos/cm	Field determination	
Alkalinity			Titration of 10 ml sample with 0.02 N H_2SO_4 to phenolphthalein and brom cresol green-methyl red end points (4).	mg/1 $CACO_3$	nearest 5 mg/1	Field determination	

PARAMETER	SAMPLE CONTAINER	PRESERVATION	METHOD OF ANALYSIS (REFERENCE)	UNITS OF MEASUREMENT	DETECTION LIMITS	ANALYSIS	GENERAL USE STANDARD
pH			Sargent-Welch model PBL pH meter, calibrated in field.		nearest 0.1 units	Field determination	in range 6.5-9.0
Nitrate + Nitrite-N	8 oz. polyethylene	10 ml - 20% H_2SO_4/1 at 4°C	Cadmium reduction method on Technicon Auto-Analyzer (3, p. 201).	mg/1 N	0.01 mg/1	Regional IEPA lab	
Ammonia-N (NH_3-N)	8 oz. polyethylene	10 ml - 20% H_2SO_4/1 at 4°C	Phenate method on Technicon Auto-Analyzer (3, p. 168)	mg/1 N	0.01 mg/1	Regional IEPA lab	1.5 mg/1
Total Kjeldahl-N	8 oz. polyethylene	10 ml - 20% H_2SO_4/1 at 4°C	Digestion at 370°C followed by determination of ammonia as above.	mg/1 N	0.1 mg/1	Champaign IEPA lab	
Total Phosphorus	8 oz. polyethylene	10 ml - 20% H_2SO_4/1 at 4°C	Digestion to convert all phosphorus forms to orthophosphate followed by determination using ascorbic acid reduction method using Technicon Auto-Analyzer (3, p. 256).	mg/1 P	0.01 mg/1	Regional IEPA lab	
Total Dissolved Phosphorus (TDP)	1 oz. polyethylene	10 ml - 20% H_2SO_4/1 at 4°C	Field filtration followed by TP analysis as above.	mgl/ P	0.01 mg/1	Regional IEPA lab	0.05 mg/1
Fecal Coliform	6 oz. glass	1 ml - 10% $NA_2S_2O_3$/1	Filtration of sample through 0.45u membrance filter followed by incubation for 24 hrs. at 44.5°C on pad containing M-FC culture media (6, p. 937).	# organisms per/100 ml	1/100 ml	Regional IEPA lab	200/100 ml
Total Mercury	6 oz. glass	20 ml - 25% K_2CR_2O7 in 50% HNO_8/1	Digestion with H_2SO_4 and potassium persulfate to convert all forms to inorganic HG followed by stannous chloride reduction step to convert all inorganic Hg to metalic Hg, then measurement by cold vapor atomic absorption (3, p. 127).	mg/1 Hg	0.05 mg/1	Champaign IEPA lab	0.5 mg/1

APPENDIX 6

Daily Discharge at Station C in CFS-Days During Water Year 1981.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.1	0.1	0.1	0.2	0.1	0.3	0.3	0.5	0.5	0.6	3.5	1.0
2	0.1	0.1	0.1	0.2	0.1	0.30	0.3	0.5	0.6	0.5	1.9	0.8
3	0.1	0.1	0.1	0.2	0.1	0.3	0.3	0.3	0.5	0.5	1.4	0.8
4	0.1	0.1	0.1	0.2	0.1	3.4	0.3	0.5	0.5	492.5	1.6	0.7
5	0.1	0.2	0.1	0.2	0.1	2.0	0.3	0.5	0.5	48.8	1.6	0.7
6	0.1	0.2	0.1	0.2	0.1	0.4	0.3	0.5	0.5	3.7	1.6	0.7
7	0.1	0.1	3.0	0.1	0.1	0.4	0.3	0.4	0.5	1.3	1.3	0.7
8	0.1	0.2	11.7	0.1	0.1	0.3	0.3	0.4	0.5	1.0	1.2	0.7
9	0.1	0.2	0.6	0.1	0.1	0.4	0.3	0.4	0.4	0.8	1.1	0.6
0	0.1	0.2	0.5	0.1	0.1	0.4	0.3	31.5	0.4	0.7	1.0	0.6
1	0.1	0.1	0.4	0.1	0.1	0.4	28.0	5.2	0.4	0.7	0.9	0.6
2	0.1	0.1	0.4	0.1	0.1	0.4	15.0	1.0	0.4	0.6	0.9	0.6
3	0.1	0.1	0.3	0.1	0.1	0.4	57.8	0.8	0.4	0.6	0.8	0.6
4	0.1	0.1	0.3	0.1	0.1	0.3	17.5	1.0	0.4	0.6	0.8	0.6
5	0.1	0.2	0.3	0.1	11.0	9.3	1.5	0.7	28.5	0.6	0.9	0.6
6	0.2	0.1	0.3	0.1	5.2	0.3	1.1	0.7	1.2	0.6	1.0	0.6
7	35.4	0.1	0.3	0.1	0.8	0.3	0.8	1.6	0.5	0.6	0.8	0.6
8	0.4	0.1	0.3	0.1	0.7	0.3	0.7	253.9	0.6	0.6	0.8	0.6
9	0.2	0.1	0.3	0.1	0.6	0.3	29.	9.9	0.6	122.0	0.8	0.6
0	0.2	0.1	0.3	0.1	0.6	0.3	0.9	2.3	0.4	7.6	0.7	0.6
1	0.2	0.1	0.3	0.1	0.6	0.3	0.8	1.4	76.9	0.9	0.7	0.6
2	0.1	0.1	0.3	0.1	0.5	0.3	5.3	1.2	9.2	0.7	0.7	0.6
3	0.1	0.1	0.3	0.1	0.5	0.3	1.0	2.9	0.7	31.6	0.7	0.6
4	0.2	0.1	9.3	0.1	0.4	0.2	0.8	1.0	124.2	1.3	0.7	0.6
5	0.2	1	0.2	0.1	0.4	0.3	0.7	0.8	67.0	97.3	0.6	0.6
6	0.2	0.1	0.2	0.1	0.4	0.3	0.6	0.7	1.9	402.9	0.6	0.5
7	0.3	0.1	0.2	0.1	0.4	0.3	0.5	0.7	0.9	239.7	0.6	0.5
8	0.3	0.1	0.2	0.1	0.4	0.3	0.5	0.6	0.7	88.2	0.6	0.5
9	0.2	0.2	0.2	0.1	-	1.6	0.5	0.6	0.6	13.2	0.6	0.5
0	0.2	0.1	0.2	0.1	-	0.3	0.5	0.6	0.6	9.0	0.7	0.5
1	0.2	-	0.2	0.1	-	0.3	-	0.6	-	6.0	1.2	-
nthly otal	40.1	3.7	22.2	3.8	23.9	16.0	140.4	323.9	320.8	1575.7	32.3	187.
orm elated	0.0	0.0	0.0	0.0	0.0	6.1	100.8	285.8	307.7	525.6	0.0	0.0

APPENDIX 7

Daily Discharge at Station B in CFS-Days During Water Year 1981.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	0.1	0.1	0.1	0.3	0.1	0.4	0.4	0.7	0.7	0.9	5.2	1.5
2	0.1	0.1	0.1	0.3	0.1	0.4	0.4	0.7	0.9	0.7	2.8	1.2
3	0.1	0.1	0.1	0.3	0.1	0.4	0.4	0.7	0.7	0.7	2.1	1.2
4	0.1	0.1	0.1	0.3	0.1	5.0	0.4	0.7	0.7	730.7	2.4	1.0
5	0.1	0.3	0.1	0.3	0.1	3.0	0.4	0.7	0.7	72.4	2.4	1.0
6	0.1	0.3	0.1	0.3	0.1	0.6	0.4	0.7	0.7	5.5	2.4	1.0
7	0.1	0.1	4.5	0.1	0.1	0.6	0.4	0.6	0.7	1.9	1.9	1.0
8	0.1	0.3	17.4	0.1	0.1	0.4	0.4	0.6	0.6	1.5	1.8	1.0
9	0.1	0.3	0.9	0.1	0.1	0.6	0.4	0.6	0.6	1.2	1.6	0.9
10	0.1	0.3	0.7	0.1	0.1	0.6	0.4	46.7	0.6	1.0	1.5	0.9
11	0.1	0.1	0.6	0.1	0.1	0.6	41.5	7.7	0.6	1.0	1.3	0.9
12	0.1	0.1	0.6	0.1	0.6	0.6	22.3	1.5	0.6	0.9	1.3	0.9
13	0.1	0.1	0.4	0.1	0.1	0.6	85.8	1.2	0.6	0.9	1.2	0.9
14	0.1	0.1	0.4	0.1	0.1	0.4	26.0	1.5	0.6	0.9	1.2	0.9
15	0.1	0.3	0.4	0.1	16.3	0.4	2.2	1.0	42.3	0.9	1.3	0.9
16	0.3	0.1	0.4	0.1	7.7	0.4	1.6	1.0	1.8	0.9	1.5	0.9
17	52.5	0.1	0.4	0.1	1.2	0.4	1.2	2.4	0.7	0.9	1.2	0.9
18	0.6	0.1	0.4	0.1	1.0	0.4	1.0	376.7	0.7	0.9	1.2	0.9
19	0.3	0.1	0.4	0.1	0.9	0.4	4.3	14.7	0.9	181.0	1.2	0.9
20	0.3	0.1	0.4	0.1	0.9	0.4	1.3	3.4	0.6	11.3	1.0	0.9
21	0.3	0.1	0.4	0.1	0.9	0.4	1.2	2.1	114.1	1.3	1.0	0.9
22	0.1	0.1	0.4	0.1	0.7	0.4	7.9	1.8	13.7	1.0	1.0	0.9
23	0.1	0.1	0.4	0.1	0.7	0.4	1.5	4.3	1.0	46.9	1.0	0.9
24	0.3	0.1	0.4	0.1	0.6	0.3	1.2	1.5	184.3	1.9	1.0	0.9
25	0.3	0.1	0.3	0.1	0.6	0.4	1.0	1.2	99.4	144.4	0.9	0.7
26	0.3	0.1	0.3	0.1	0.6	0.4	0.9	1.0	2.8	597.8	0.9	0.7
27	0.4	0.1	0.3	0.1	0.6	0.4	0.7	1.0	1.3	355.7	0.4	0.7
28	0.4	0.1	0.3	0.1	0.6	0.4	0.7	0.9	1.0	130.9	0.9	0.7
29	0.3	0.3	0.1	0.1		2.4	0.7	0.9	0.9	19.6	0.9	0.7
30	0.1	0.3	0.1	0.1		0.4	0.7	0.9	0.9	13.4	1.0	0.7
31	0.3	-	0.3	0.1	-	0.4		0.9	0	8.9	1.8	-
Monthly Total	58.6	4.4	32.2	4.3	34.7	22.9	207.7	480.3	475.7	2239.9	47.8	27.5
Storm Related	0.0	0.0	0.0	0.	0.0	9.0	149.6	424.0	456.7	779.8	0.0	0.0

APPENDIX 8

Daily Discharge at Station A in CFS-Days During Water Year 1981.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	0.0	0.1	0.0	0.0	0.0	11.4	12.7	16.7	16.7	23.3	146.1	34.1
	0.0	0.0	0.0	0.0	0.0	11.4	11.4	15.3	16.7	19.5	77.2	25.7
	0.0	0.0	0.0	0.0	0.0	10.8	10.2	14.0	15.3	18.1	52.1	21.0
	0.0	0.0	0.0	0.0	0.0	12.1	9.6	13.3	14.6	61.1	40.4	19.5
	0.0	0.0	0.0	0.0	0.0	24.1	9.1	13.3	13.3	61.6	32.3	15.3
	0.0	0.0	0.0	0.0	0.0	22.5	9.1	12.7	12.7	57.0	26.5	13.3
	0.0	0.0	0.0	0.0	0.0	19.5	8.0	12.1	11.4	197.4	22.5	11.4
	0.0	0.0	1.7	0.0	0.0	17.4	6.9	11.4	11.4	93.9	19.5	10.8
	0.0	0.0	5.9	0.0	0.0	15.3	9.1	10.2	10.8	58.4	17.4	11.4
	0.0	0.0	5.9	0.0	0.0	14.0	9.1	32.3	9.1	40.4	18.1	10.8
	0.0	0.0	4.5	0.0	0.0	12.7	51.1	53.2	8.5	29.8	17.4	9.1
	0.0	0.0	4.0	0.0	0.0	12.1	72.6	46.2	9.1	24.1	16.7	9.1
	0.0	0.0	3.6	0.0	0.0	11.4	96.4	38.6	9.6	21.0	14.6	9.1
	0.0	0.0	2.8	0.0	0.0	10.8	98.9	34.1	9.6	18.1	13.3	9.1
	0.0	0.0	2.1	0.0	0.0	10.8	77.2	31.5	9.6	16.0	17.4	9.6
	0.0	0.0	1.4	0.0	0.0	10.2	53.2	28.1	38.6	16.7	16.7	9.1
	13.3	0.0	1.1	0.0	0.0	9.1	39.5	24.1	31.5	15.3	16.7	7.4
	10.8	0.0	0.6	0.0	0.0	8.0	33.2	56.7	22.5	14.0	16.0	6.4
	5.9	0.0	0.2	0.0	0.0	6.9	30.6	49.7	51.1	136.2	12.7	4.9
	3.6	0.0	0.0	0.0	0.0	6.4	30.6	139.0	34.1	44.4	11.4	4.5
	1.7	0.0	0.0	0.0	0.0	6.9	28.9	80.7	62.6	106.6	10.8	4.0
	1.4	0.0	0.0	0.0	0.0	5.9	28.1	53.2	139.0	61.6	10.8	4.0
	0.6	0.0	0.0	0.0	18.1	6.9	28.1	43.3	79.5	51.1	10.2	2.4
	0.4	0.0	0.0	0.0	18.1	7.4	26.5	39.5	59.4	72.6	9.1	1.7
	0.4	0.0	0.0	0.0	16.7	6.9	24.9	32.3	46.1	51.1	9.1	1.7
	0.0	0.0	0.0	0.0	15.3	6.9	22.5	28.9	121.1	61.1	9.1	1.4
	0.6	0.0	0.0	0.0	14.0	6.9	21.0	25.7	73.7	61.1	8.5	2.4
	0.4	0.0	0.0	0.0	12.7	6.9	20.3	22.5	45.2	61.1	9.6	1.7
	0.4	0.0	0.0	0.0	-	12.7	18.1	19.5	34.1	61.1	10.8	1.1
	0.4	0.0	0.0	0.0	-	15.3	18.1	18.1	28.9	61.1	9.6	1.4
	0.0	-	0.0	0.0	-	14.0	-	17.4	-	51.8	13.3	-
hly al	39.9	0.1	0.0	0.0	94.9	353.9	915.0	1033.6	1045.8	1666.1	715.9	273.4
m lated	0.0	0.0	0.0	0.0	0.0	65.9	220.1	99.2	437.8	211.0	6.0	0.0

APPENDIX 9

1981 Ambient Lake Data, Pittsfield City Lake, Pike County, Illinois

Parameter	DATE	SITE 1	SITE 2	SITE 3	MEAN	STD DEV	DATE	SITE 1	SITE 2	MEAN	STD DEV
TSS	04/29	12.000	14.000	15.000	13.667	1.528	04/29	10.000	32.000	21.000	15.556
	06/03	9.000	12.000	39.000	20.000	16.523	06/03	18.000	19.000	18.500	0.707
	06/30	106.000	16.000	33.000	51.667	47.816	06/30	21.000	110.000	65.500	62.933
	08/13	11.000	17.000	20.000	16.000	4.583	08/13	86.000	58.000	72.000	19.799
	09/10	15.000	15.000	36.000	22.000	12.124	09/10	36.000	24.000	38.000	8.485
	19.29	22.000	25.000	36.000	27.667	7.371	10/20	47.000	43.000	45.000	2.828
	*SUMMARY STATISTICS***				LAKE MEAN		***SUMMARY STATISTICS***			LAKE MEAN	
	MEAN	42.333	14.000	29.000	28.444			14.000	25.500	19.750	
	STD DEV	55.157	2.000	12.490	30.843			5.657	9.192	9.106	
	MIN	9.000	12.000	15.000	9.000			10.000	19.000	10.000	
	MAX	106.000	16.000	39.000	106.000			18.000	32.000	32.000	
VSS	04/29	5.000	4.000	7.000	5.333	1.528	04/29	2.000	6.000	4.000	2.828
	06/03	4.000	7.000	8.000	6.333	2.082	06/03	1.000	1.000	1.000	0.000
	06/30	22.000	5.000	8.000	11.667	1.528	06/30	9.000	14.000	11.500	3.536
	08/13	7.000	5.000	8.000	6.667	1.555	08/13	21.000	9.000	15.000	1.414
	10/20	3.000	6.000	7.000	5.333	2.082	10/20	9.000	7.000	8.000	1.414
	*SUMMARY STATISTICS***				LAKE MEAN		***SUMMARY STATISTICS***			LAKE MEAN	
	MEAN	10.333	5.333	7.667	7.778			1.500	3.500	2.500	
	STD DEV	10.116	1.528	0.577	5.563			0.707	3.536	2.380	
	MIN	4.000	4.000	7.000	4.000			1.000	1.000	1.000	
	MAX	22.000	7.000	8.000	22.000			2.000	6.000	6.000	
TURB	04/29	9.00	10.000	10.000	9.667	0.577	04/29	16.000	28.000	22.000	8.485
	06/03	7.000	8.000	26.000	13.667	10.693	06/03	50.000	43.000	46.500	4.950
	06/30	90.000	16.000	21.000	42.333	41.356	06/30	21.000	120.000	70.500	70.004
	08/13	6.000	12.000	12.000	10.000	3.464	08/13	54.000	48.000	51.000	4.243
	09/10	3.000	3.500	6.000	4.167	1.607	29/10	8.600	5.400	7.000	2.623
	10/20	4.400	4.300	5.600	4.767	0.723	10/20	28.000	8.690	18.300	13.718
	*SUMMARY STATISTICS***				LAKE MEAN		***SUMMARY STATISTICS***			LAKE MEAN	
	MEAN	35.333	11.333	10.000	21.889			33.000	35.500	34.250	
	STD DEV	47.353	4.163	8.185	26.351			24.042	10.607	15.240	
	MIN	7.000	3.000	10.000	7.000			16.000	28.000	16.000	
	MAX	90.000	16.000	26.000	90.000			50.000	43.000	50.000	

1981 Ambient Lake Data, Pittsfield City Lake, Pike County, Illinois

			TOP						BOTTOM		
Parameter	DATE	SITE 1	SITE 2	SITE 3	MEAN	STD DEV	DATE	SITE 1	SITE 2	MEAN	STD DEV
TKN	04/29	1.000	2.100	1.900	1.667	0.586	04/29	1.300	1.200	1.250	0.071
	06/03	1.500	1.200	1.500	1.400	0.173	06/03	0.900	0.900	0.900	0.000
	06/30	2.600	1.200	1.400	1.733	0.757	06/30	21.000	110.000	65.500	62.933
	08/13	11.000	17.000	20.000	16.000	4.583	08/13	86.000	58.000	72.000	19.799
	09/10	15.000	15.000	36.000	22.000	12.142	09/10	36.000	24.000	38.000	8.485
	10/20	22.000	25.000	36.000	27.667	7.371	10/20	47.000	43.000	45.000	2.828
	*SUMMARY STATISTICS***				LAKE MEAN		***SUMMARY STATISTICS***			LAKE MEAN	
	MEAN	1.700	1.500	1.600	1.600			1.100	1.050	1.075	
	STD DEV	0.819	0.528	0.265	0.518			0.283	0.212	0.286	
	MIN	1.000	1.200	1.400	1.000			0.900	0.900	0.900	
	MAX	2.600	2.100	1.900	2.600			1.300	1.200	1.300	
NH3-N	04/29	0.028	0.050	0.030	0.033	0.015	04/29	0.500	0.400	0.450	0.071
	06/03	0.170	0.210	0.390	0.257	0.117	06/03	0.000	0.000	0.000	0.000
	06/30	1.200	0.040	0.050	0.430	0.667	06/30	0.050	0.690	0.370	0.453
	08/13	0.040	0.010	0.010	0.020	0.17	08/13	2.100	0.680	1.390	1.004
	09/10	0.050	0.020	0.60	0.043	0.021	09/10	1.800	0.100	0.950	1.202
	10/20	0.080	0.830	0.840	0.850	0.926	10/20	8.120	0.060	0.135	0.106
	*SUMMARY STATISTICS***				LAKE MEAN		***SUMMARY STATISTICS***			LAKE MEAN	
	MEAN	0.463	0.100	0.157	0.240			0.250	0.200	0.225	
	STD DEV	0.6452	0.095	0.202	0.380			0.354	0.283	0.263	
	MIN	0.020	0.040	0.030	0.020			0.000	0.000	0.000	
	MAX	1.200	0.210	0.390	1.200			0.500	0.400	0.500	
N32	04/29	0.220	0.190	0.290	0.230	0.056	04/29	0.378	0.350	0.360	0.014
	06/03	0.120	0.300	0.790	0.400	0.341	06/03	1.700	1.400	1.550	0.212
	06/30	0.040	0.010	0.070	0.040	0.030	06/30	0.040	0.210	0.125	0.120
	08/13	0.010	0.010	0.010	0.010	0.000	08/13	0.010	0.020	0.015	0.007
	20/10	0.010	0.010	0.010	0.010	0.000	09/10	0.010	0.010	0.010	0.000
	10/20	0.110	0.110	0.230	0.150	0.000	09/10	0.000	0.000	0.000	0.000
	*SUMMARY STATISTICS***				LAKE MEAN		***SUMMARY STATISTICS***			LAKE MEAN	
	MEAN	0.127	0.163	0.380	0.223			1.035	0.875	0.955	
	STD DEV	0.090	0.146	0.363	0.233			0.940	0.742	0.698	
	MIN	0.040	0.010	0.070	0.370			0.370	0.350	0.350	
	MAX	0.220	0.300	0.780	0.780			1.700	1.400	1.700	

1981 Ambient Lake Data, Pittsfield City Lake, Pike County, Illinois

Parameter	DATE	SITE 1	TOP SITE 2	SITE 3	MEAN	STD DEV	DATE	SITE 1	BOTTOM SITE 2	MEAN	STD DEV
PTL	04/29	0.085	0.160	0.156	0.136	0.045	04/29	0.106	0.121	0.114	0.011
	06/03	0.088	0.102	0.221	0.137	0.073	06/03	0.142	0.140	0.146	0.008
	06/30	0.356	0.121	0.169	0.215	0.124	06/30	0.150	0.486	0.318	0.238
	08/13	0.085	0.085	0.104	0.091	0.011	08/13	0.607	0.204	0.406	0.285
	09/10	0.041	0.049	0.084	0.058	0.023	09/10	0.304	0.064	0.184	0.170
	10/20	0.100	0.130	0.150	0.127	0.025	10/20	0.180	0.140	0.160	0.028
	*SUMMARY STATISTICS***				LAKE MEAN		***SUMMARY STATISTICS***			LAKE MEAN	
	MEAN	0.176	0.130	0.182	0.163			0.129	0.131	0.130	
	STD DEV	0.156	0.034	0.034	0.085			0.033	0.013	0.020	
	MIN	0.085	0.102	0.156	0.085			0.016	0.121	0.106	
	MAX	0.356	0.168	0.221	0.356			0.152	0.140	0.152	
DSP	04/29	0.007	0.039	0.018	0.021	0.016	04/29	0.041	0.028	0.035	0.009
	06/03	0.020	0.026	0.052	0.033	0.017	06/03	0.078	0.089	0.084	0.007
	09/10	0.003	0.006	0.009	0.006	0.003	09/10	0.232	0.015	0.124	0.153
	10/20	0.040	0.040	0.040	0.040	0.000	10/20	0.060	0.040	0.050	0.014
	*SUMMARY STATISTICS***				LAKE MEAN		***SUMMARY STATISTICS***			LAKE MEAN	
	MEAN	0.010	0.024	0.026	0.020			0.060	0.059	0.059	
	STD DEV	0.009	0.017	0.023	0.017			0.027	0.084	0.029	
	MIN	0.003	0.006	0.009	0.003			0.041	0.028	0.028	
	MAX	0.028	0.039	0.052	0.052			0.079	0.089	0.0089	
CHLORIDE	04/29	9.300	9.600	9.700	9.533	04/29	0.300	9.400	9.350	0.071	
	*SUMMARY STATISTICS***				LAKE MEAN		***SUMMARY STATISTICS***			LAKE MEAN	
	MEAN	9.300	9.600	9.700	9.533			9.300	9.400	9.350	
	STD DEV	-1.000	-1.000	-1.000	-1.000			-1.000	-1.000	-1.000	
	MIN	9.300	9.600	9.700	9.300			9.300	9.400	9.300	
	MAX	9.300	9.600	9.700	9.700			9.300	9.400	9.400	

1981 Ambient Lake Data, Pittsfield City Lake, Pike County, Illinois

			TOP						BOTTOM		
Parameter	DATE	SITE 1	SITE 2	SITE 3	MEAN	STD DEV	DATE	SITE 1	SITE 2	MEAN	STD DEV
T-ALK	06/03	120.000	130.000	138.000	129.333	9.018	06/03	120.000	120.000	120.000	0.000
	06/30	122.000	129.000	132.000	127.667	5.132	06/30	99.000	122.000	120.500	16.263
	08/13	100.000	100.000	108.000	182.667	5.619	08/13	156.000	100.000	128.000	39.598
	09/10	120.000	125.000	120.000	121.667	2.887	09/10	150.000	115.000	132.500	24.749
	10/20	136.000	120.000	-1.000	128.000	11.314	10/20	124.000	126.000	125.000	1.414
	*SUMMARY STATISTICS***				LAKE MEAN		***SUMMARY STATISTICS***			LAKE MEAN	
	MEAN	114.000	119.667	126.000	119.889			189.500	121.000	115.250	
	STD DEV	12.166	17.039	15.875	14.128			14.949	1.414	10.874	
	MIN	100.000	100.000	108.000	100.000			99.000	120.000	99.000	
	MAX	122.000	130.000	138.000	138.000			120.000	122.000	122.000	
P-ALK	06/03	10.000	20.000	10.000	13.333	5.774	06/03	0.000	0.000	0.000	0.000
	06/30	20.000	20.000	20.000	20.000	0.000	06/30	0.000	0.000	0.000	0.000
	08/13	26.000	12.000	11.000	16.333	8.836	08/13	0.000	0.000	0.000	0.000
	09/10	0.000	0.000	0.000	0.000	0.000	09/10	0.000	0.000	0.000	0.000
	10/20	0.000	0.000	-1.000	0.000	0.000	10/20	0.000	0.000	0.000	0.000
	*SUMMARY STATISTICS***				LAKE MEAN		***SUMMARY STATISTICS***			LAKE MEAN	
	MEAN	18.667	17.333	13.667	16.565			0.000	0.000	0.000	
	STD DEV	8.083	4.619	5.508	5.855			0.000	0.000	0.000	
	MIN	10.000	12.000	10.000	10.000			0.000	0.000	0.000	
	MAX	26.000	20.000	20.000	26.000			0.000	0.000	0.000	
COND	06/03	295.000	280.000	300.000	291.667	10.408	06/03	300.000	320.000	310.000	14.142
	06/30	248.000	255.000	274.000	259.000	13.454	06/30	319.000	295.000	307.000	16.971
	08/13	184.000	190.000	201.000	191.667	8.522	08/13	324.000	276.000	300.000	33.941
	09/10	231.000	236.000	246.000	273.667	7.638	09/10	380.000	257.000	318.500	86.974
	10/20	293.000	299.000	385.000	299.000	6.000	10/20	297.000	303.000	300.000	4.243
	*SUMMARY STATISTICS***				LAKE MEAN		***SUMMARY STATISTICS***			LAKE MEAN	
	MEAN	242.333	241.667	258.333	247.444			309.500	307.500	308.500	
	STD DEV	55.717	46.453	51.326	45.178			13.435	17.678	12.817	
	MIN	134.000	190.000	201.000	194.000			300.000	295.000	295.000	
	MAX	295.000	280.000	300.000	300.000			319.000	320.000	320.000	

1981 Ambient Lake Data, Pittsfield City Lake, Pike County, Illinois

Parameter	DATE	SITE 1	TOP SITE 2	SITE 3	MEAN	STD DEV	DATE	SITE 1	BOTTOM SITE 2	MEAN	STD DEV
D.O.	06/03	13.000	13.000	12.300	12.767	0.404	06/03	0.000	0.000	0.000	0.000
	06/30	8.400	13.700	10.500	10.867	2.669	06/30	0.000	-1.000	0.000	-1.000
	08/13	18.702	15.400	13.600	15.900	2.587	08/13	0.000	1.100	0.550	0.778
	09/10	5.602	11.000	11.700	9.433	3.338	08/10	0.000	3.800	1.900	2.687
	10/20	6.800	8.700	18.400	11.300	6.22	10/20	4.400	6.500	5.450	1.485
	*SUMMARY STATISTICS***				LAKE MEAN		***SUMMARY STATISTICS***			LAKE MEAN	
	MEAN	13.367	14.033	12.133	13.178			0.000	0.000	0.000	
	STD DEV	5.160	1.234	1.557	2.888			0.000	-1.000	0.000	
	MIN	8.400	13.000	10.500	8.400			0.000	0.000	0.000	
	MAX	18.700	15.400	13.600	18.700			0.000	0.000	0.000	
D.O.	06/03	8.300	-1.000	-1.000	8.300	-1.000					
	06/30	8.700	8.700	9.000	8.800	0.173	06/30	7.300	7.500	7.400	0.141
	08/13	8.300	8.100	9.000	8.467	0.473	08/13	6.600	6.600	6.700	0.141
	09/10	7.100	8.400	8.500	8.000	0.781	09/10	6.600	7.100	6.850	0.354
	10/20	8.500	7.600	8.600	8.233	0.551	10/20	7.300	7.500	7.400	0.141
	*SUMMARY STATISTICS***				LAKE MEAN		***SUMMARY STATISTICS***			LAKE MEAN	
	MEAN	13.367	14.033	12.133	13.178			0.000	0.000	0.000	
	STD DEV	5.160	1.234	1.557	2.888			0.000	-1.000	0.000	
	MIN	8.400	13.000	10.500	8.400			0.000	0.000	0.000	
	MAX	18.700	15.400	13.600	18.700			0.000	0.000	0.000	
COD	04/29	27.000	49.000	41.000	39.000	11.136	04/29	21.000	24.000	22.500	2.121
	06/03	24.000	22.000	23.000	23.000	1.000	06/03	18.000	19.000	18.000	0.000
	06/30	31.000	28.000	27.0		28.667	06/30	27.000	31.000	29.000	2.828
	08/13	19.000	19.000	21.000	19.667	1.155	08/13	35.000	28.000	27.500	10.607
	09/10	21.000	21.000	25.000	22.333	2.309	09/10	23.000	22.000	22.500	0.707
	10/20	16.000	20.000	74.000	36.667	32.393	10/20	20.000	18.000	19.000	1.414
	*SUMMARY STATISTICS***				LAKE MEAN		***SUMMARY STATISTICS***			LAKE MEAN	
	MEAN	13.367	14.033	12.133	13.178			0.000	0.000	0.000	
	STD DEV	5.160	1.234	1.557	2.888			0.000	-1.000	0.000	
	MIN	8.400	13.000	10.500	8.400			0.000	0.000	0.000	
	MAX	18.700	15.400	13.600	18.700			0.000	0.000	0.000	

1981 Ambient Lake Data, Pittsfield City Lake, Pike County, Illinois

			TOP						BOTTOM		
Parameter	DATE	SITE 1	SITE 2	SITE 3	MEAN	STD DEV	DATE	SITE 1	SITE 2	MEAN	STD DEV
TEMP	06/03	18.800	19.100	19.900	19.267	0.569	06/03	8.100	9.000	8.550	0.636
	06/30	26.900	27.000	27.800	27.533	0.551	06/30	14.400	-1.000	14.400	-1.000
	08/13	25.600	26.500	27.400	26.500	0.900	08/13	16.200	20.000	18.100	2.687
	09/10	23.600	23.700	24.000	24.033	0.666	09/10	16.600	21.800	19.200	3.677
	10/20	15.300	15.400	15.500	15.400	0.100	10/20	14.500	14.300	14.400	0.141
	*SUMMARY STATISTICS***				LAKE MEAN		***SUMMARY STATISTICS***			LAKE MEAN	
	MEAN	23.767	24.467	25.067	24.433			11.250	9.000	10.500	
	STD DEV	4.350	4.693	4.481	3.947			4.455	-1.000	3.407	
	MIN	18.800	19.100	19,900	18.800			8.100	0.000	8.100	
	MAX	26.900	27.800	27.900	27.900			14.400	9.000	14.400	
FECAL	04/29	20.000	30.000	20.000	23.333	5.774					
	*SUMMARY STATISTICS***				LAKE MEAN						
	MEAN	20.000	30.000	20.000	23.333						
	STD DEV	-1.000	-1.000	-1.000	5.774						
	MIN	20.000	30.000	20.000	20.000						
	MAX	20.000	30.000	20.000	30.000						

TED:dks:sp/4599c, 1-31

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RX
SA      WATER QUALITY DATA BLUE CREEK                                                                                  WATER QUALITY DATA BLUE CREEK
SA ID DATE  TIME   TSS   TVS  TKN  COD   NH3   N32  PTL   DSP   KTL   FET   BOD TEM  PH  DOXY CON  TUB
ST.A800502  1145     7     3
ST.A800505  1130    14     7
ST.A800507  0920    12     5  1.4   26   0.0   0.0 0.09         6.4   130        16
ST.A800507  0925    14     9
ST.A800509  1030    14     6
ST.A800512  1120    12     4                                                      18
ST.A800514  0920    13     7  1.5   21   0.1   0.0 0.08         4.9   270    10  15
ST.A800514  0955
ST.A800514  1010    17     3                                                      15  8.9 10.7 292
ST.A800516  1430    12     4
ST.A800519  1445     9     4                                                      16
ST.A800521  1000   170    21                                                      18
ST.A800521  1000    17     9  1.5   30   0     0   0.12         13    130    10  19  8.3 18.0 355
ST.A800523  1000     8     4
ST.A800526  0900    18    10                                                      19
ST.A800528  0900    13   0.0                                                      23
ST.A800528  0900    11     5  1.0   25   0.0   0.0 0.06         4.4    60     6  23  7.7  9.0 285
ST.A800530  1430    24     3                                                      25
ST.A800602  1400    20     8                                                      23
ST.A800604  1330    14     2
ST.A800605  0800    12     0  1.1   19   0.2   0.1 0.12         4.7   740     4  21  7.5  4.7 285
ST.A800606  1055    16     3                                                      25
ST.A800609  1400    23     3                                                      24
ST.A800611  0915    11     3
ST.A800611  0915    15     5  1.2   20   0     0                4.8   460     8  22  8.4 13.1 285
ST.A800613  1010     9     3                                                      22
ST.A800616  1050    11     1
ST.A800618  0730     9     1  1.0   17   0     0   0.05         4.8   180     4  23  8.5  9.7 290
ST.A800620  1050     9     1                                                      24
ST.A800623  1005     5     3                                                      25
ST.A800625  0700     5     4  0.5   18   0     0   0.05         3.7   240     4  24  7.6  7.8 308
ST.A800627  1355    13     4                                                      30
ST.A800630  1135     9     8                                                      29
ST.A800702  0825     8     2  0.6   25   0     0   0.06        4.68   200     4  27  8.4  9.8 300
ST.A800704  1040    17     4                                                      28
ST.A800707  1150     3     2                                                      30
ST.A800709  0830     4     1  1.1   20   0     0   0.06         5.9   390     3  29       7.2 325
ST.A800711  1105     7   0.0                                                      32
ST.A800714  1230    10     1                                                      32
ST.A800716  0910    11     3  0.6   19   0     0   0.05         4.6   210     4  30       7.8 275
ST.A800718  1445    15   0.0                                                      31
ST.A800721  1035    12     2                                                      30
ST.A800723  0950    14     1  0.6   17   0     0   0.05         5.5   270     3  29  8.9  7.3 290
ST.A800725  1115     9     3                                                      28
ST.A800728  1405     9     2                                                      29
ST.A800730  0945    10     1  0.8   20   0     0   0.04         0.6   200     4  27       9.1 320
ST.A800804  1015     8     4                                                      27
ST.A800806  0945    12     6  0.6   20   0     0   0.05         5.0   280     3  27  7.7  6.3 280
ST.A800809  1010     9     1                                                      28
ST.A800811  0945     4   0.0                                                      28
ST.A800813  0925     5     1  0.8   19   0     0   0.04         5.1   200     4  27  9.7  7.9 290
ST.A800815  1415    10     4                                                      28
ST.A800818  1030     7     3                                                      28
ST.A800820  1130     6     2  0.6   18             0.05         4.3   270     3  30  8.4 12.7 265
ST.A800822  1610     7     2                                                      31
ST.A800825  0915     2     0                                                      27
ST.A800827  0850     1     0  0.6   17             0.03         4.2   120     3  27       8.9 250
ST.A800901  1915   INSUFFICIENT SAMPLE                                            27
ST.A800903  0845     6     2  0.9   15   0.1       0.04         4.1   230     3  26       5.6 270
ST.A800905  1520    11     3                                                      25
ST.A800908  0940     8     3                                                      25
ST.A800910  0910    12     3  0.8   18             0.05         4.4   220     4  25  6.7  7.9 220
ST.A800912  1400     7     0                                                      26
ST.A800915  1350    12     2                                                      26
ST.A800917  0920    15     5  0.9   24   0.3   0.1 0.05         5.2  1100     2  23  6.6  5.2 265
ST.A800919  1435     9     7                                                      24
ST.A800922  1010    14     5                                                      25
ST.A800924  1315    16     4  0.9   20   0.1   0.2 0.07         5.5   310     7  24  7.5 10.2 305
ST.A800926  1550    10     0                                                      23
ST.A800929  1330    12     6                                                      21
ST.A801001  0915    10     3  0.8   17   0.1   0.1 0.05         5.4   140     5  20  7.7  7.9 294
ST.A801003  1000    12     3                                                      18
ST.A801006  1405    10     2                                                      19
ST.A801008  0920     5     3  0.8   15   0.1   0.4 0.05        4.35   270     4  18  7.6  8.4 295
ST.A801010  1325    27     5                                                      19
ST.A801013  1135    14     2                                                      16
ST.A801015  0920    14     2  0.7   18   0.1   0.3 0.06         4.3   710     5  16  7.6  7.7 305
ST.A801022  0930                                                                  14  7.5  8.3 300
ST.A801029  0900    15     4  0.6   17   0.1   0.4 0.08         5.7   410     5   9  7.6  9.8 305
ST.A801031  1450    10     4                                                      14
ST.A801103  0950    13     5                                                      10
[illegible]         14     4  0.8   14   0.3   0.6 0.08         5.3   490     5   9  7.1  9.7 315
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ST.A801010 1325   27    5                                              19
ST.A801013 1135   14    2                                              16
ST.A801015 0920   14    2   0.7   18  0.1  0.3  0.06      4.3  710   5 16  7.6  7.7 305
ST.A801022 0930                                                        14  7.5  8.3 300
ST.A801029 0900   15    4   0.6   17  0.1  0.4  0.08      5.7  410   5  9  7.6  9.8 305
ST.A801031 1450   10    4                                              14
ST.A801103 0950   13    5                                              10
ST.A801105 0900   14    4   0.9   16  0.1  0.6  0.08      5.3  480   5  9  7.3  9.7 315
ST.A801107 1430   12    3                                              12
ST.A801110 0940   14    3                                              11
ST.A801112 1130   15    4   0.8   14  0.1  1.3  0.07      5.3  580   4 10  8.0 11.9 245
ST.A801114 1045   14    2                                               9
ST.A801117 1130   11    3                                               8
ST.A801119 0900   11    3   0.7   15  0.1  0.4  0.06      5.2  300   3  8  7.7 11.4 330
ST.A801121 0955   10    2                                               6
ST.A801124 0940   12    2   0.8   19  0.1  0.5  0.06      5.4  410   3  6  7.7 11.8 331
ST.A801126 1140    8    1                                               6
ST.A801128 1400    7    1                                               5
ST.A801201 1450    8    2                                               9
ST.A801203 0900                                                         3  8.1 13.4 339
ST.A801205 1030    6    3                                               5
ST.A801208 1000   17    4                                               5
ST.A801210 1020                                                         3  7.8 13.5 363
ST.A801218 0925    4    2   0.7   20       0.3  0.05      5.7  200   3  3  7.6 13.2 330
ST.A810227 1005    2    0                                               6
ST.A810302 1445    9    1                                               6
ST.A810304 1100    6    1                                               6
ST.A810305 1020    8    1   0.9   14       0.4  0.05      5.8  200   2  4  7.4      355
ST.A810306 1420    9    2                                               6                6.6
ST.A810309 15.5    6    2                                               6                5.0
ST.A810311 0950    6    1   0.8   21       0.3  0.05      5.8  200   2  8  7.6      355 5.3
ST.A810313 1035    7    2                                               8                5.4
ST.A810316 1010    6    1                                               7                6.
ST.A810318 1000   10    3   1.0   18  0.0  0.3  0.05      5.4  0.2   3  8  7.7      340 6.5
ST.A810320 0950   12    3                                               8                7.4
ST.A810323 0900   10    4                                               7                6.7
ST.A810325 1000   24    7   0.9   23  0.0  0.2  0.06      5.5  300   5 10  8.4 10.9 330
ST.A810327 0940    8    2                                               9                7.1
ST.A810330 1825   12    3                                              13                7.1
ST.A810401 0840   24    5   1.2   20  0.0  0.1  0.07      5.5  0.5   5 13  8.2 10.1 306 7.1
ST.A810403 1410   17    3                                              14                6.7
ST.A810406 1140   16    5                                              15                6.3
ST.A810408 1340   14    4                                              15
ST.A810409 0930   10    4   1.0   22  0.1       0.08      5.5  400   3 14  8.2  8.3 350
ST.A810410 1155   13    3                                              15                6.5
ST.A810413 1130    8    8                                              17                7.1
ST.A810415 1355  161   98   1.1   22  0.1  0.2  0.12      5.9 1200   3 16  7.9  7.0 332 33.
ST.A810417 1100   52    8                                              20                35
ST.A810420 1230   63    7                                              17                35
ST.A810422 1330   25    4   1.0   25       0.2  0.10      5.3  700   3 16  8.0  7.9 342 19.
ST.A810424 1030   12    3                                              16
ST.A810427 1135   13    4                                              20
ST.A810429 1015   14    4   1.1   26  0.0  0.3  0.07      5.5  400   5
ST.A810501 1135   24    4                                              21                14.
ST.A810504 1130   15    4
ST.A810506 1015   14    2   1.0   21       0.3  0.07      5.6  400   4 18  8.2  8.3 327
ST.A810508 1010    9    3                                              16                12.
ST.A810511 1015  444    6                                              15                24.
ST.A810511 1030   80    9   1.0   22            0.33
ST.A810511 1630   19    4   0.9   21            0.07
ST.A810512 1000  111   25   0.8   18            0.06                   15                9.5
ST.A810512 1615   17    3   0.7   16            0.19
ST.A810512 1630   52    7   0.8   15            0.09
ST.A810513 1025   14    3   0.9   16            0.08                   16                13.
ST.A810513 1030   52    7   0.7   14            0.18
ST.A810513 1630   13    4   0.9   19            0.08
ST.A810514 0830   11    3   0.9   21  0.1  0.4  0.08      5.4 1900   5 15  7.7  6.9 328 10.
ST.A810515 1810   17    2                                                                14.
ST.A810516 1240   15    5                                                                10.
ST.A810517 1455    4    1                                              15                5.5
ST.A810518 0810   25    5   0.9   16            0.09
ST.A810518 1700  280   28   1.6   31            0.42
ST.A810519 1325   56   16   1.4   23            0.22                   14                77.
ST.A810520 1000   30   18   1.5   20  0.1  0.5  0.18      5.3 2400   6 16  7.8  8.2 303 53.
ST.A810521 1030   20    7                                              16                36.
ST.A810522 0945   18    2                                              16                31.
ST.A810523 1350   21    1                                              18                43.
ST.A810524 1615   29    5                                              17                24.
ST.A810525 0730   17    1                                              20                17.
ST.A810526 1105   18    6   1.5   29  0.0  0.4   .13      5.5  400   9 20  8.6 14.0 302
ST.A810527 0700   19    3                                              21                14.
ST.A810529 1035   15    4                                              23                11.
ST.A810601 1025   14    1                                              24                12.
ST.A810603 1010   11    5   1.3   24  0.0  0.1   .08      5.0  200   6 24  8.6  9.9 284
ST.A810605 1020   17    4                                              22                8.
ST.A81[illegible]
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ST.A810513 1035   13   4   0.9   19               0.08
ST.A810514 0830   13   3   0.9   21   0.1   0.4   0.08          5.4  1900   5  15   7.7   6.9 328   10.
ST.A810515 1810   17   2                                                                          14.
ST.A810516 1240   15   5                                                                          10.
ST.A810517 1455    6   1                                                           15             5.5
ST.A810518 0810   25   5   0.9   16               0.09
ST.A810518 1700  280  28   1.6   31               0.42
ST.A810519 1325   56  16   1.4   23               0.22                                14          77.
ST.A810520 1000   30  18   1.5   20   0.1   0.5   0.18          5.3  2400   6  16   7.8   8.2 303   53.
ST.A810521 1030   20   7                                                           16             36.
ST.A810522 0945   18   2                                                           16             31.
ST.A810523 1350   21   1                                                           18             43.
ST.A810524 1615   29   5                                                           17             24.
ST.A810525 0730   17   3                                                           20             17.
ST.A810526 1105   18   6   1.5   29   0.0   0.4    .13          5.5   400   9  20   8.6  14.0 302
ST.A810527 0900   19   3                                                           21             14.
ST.A810529 1035   15   4                                                           23             11.
ST.A810601 1025   14   1                                                           24             12.
ST.A810603 1010   11   5   1.3   24   0.0   0.1    .08          5.0   200   6  24   8.6   9.9 284
ST.A810605 1020   17   4                                                           22             8.
ST.A810608 1010   12   5                                                           25             7.7
ST.A810610 0935   11   4   1.1   22   0.1   0.1    .08          5.0   200   6  25   8.6   6.3 296   6.6
ST.A810612 1000   12   3                                                           23             8.7
ST.A810615 1030   21   4                                                           24             11.
ST.A810615 2140   24   4   1.0   25               0.08
ST.A810616 1030   39   6                                                           25             14.
ST.A810616 1615   22   4
ST.A810617 0945   23   4                                                           24             15.
ST.A810617 2100   19   4
ST.A810618 0815   25   5   1.0   24   0.0   0.1    .10          4.1   590   5  24   8.4   7.8 295
ST.A810619 1345   20   5                                                           25             15.
ST.A810619 2130   16   4   0.9   23               0.09
ST.A810620 1055   24   5                                                           25             14.
ST.A810620 2110   16   4   0.9   26                     0.09
ST.A810621 0810   16   4                                                           24             13.
ST.A810622 1100   41   6                                                           23             23.
ST.A810622 2145   31   7   1.2   27                     0.13
ST.A810623 1100   41   7                                                           24             29.
ST.A810623 2140   26   3   1.2   25               0.13
ST.A810624 0745   40   6
ST.A810625 1225   40   6                                                           25             36.
ST.A810626 1035   34   7                                                           26             39.
ST.A810627 0910   28   6                                                           26             67.
ST.A810628 0655   23   6                                                           25             41.
ST.A810629 1040   24  12                                                           26             38.
ST.A810630 0755   34   8   1.2   28   0.0   0.2    .15          5.8   1.4   8  26   8.5   7.3 253
ST.A810701 1000   19   4                                                           27             20.
ST.A810703 1510   17   6                                                           27             12.
ST.A810704 1200   18   0
ST.A810704 2015  240   5   1.1   22               0.15
ST.A810705 1030  272   4                                                           26             51.
ST.A810705 2200   11   2   1.0   27               0.19
ST.A810706 1005   24   2                                                           28             41.
ST.A810706 2145   28   0   1.1   27               0.19
ST.A810707 1015   23   1                                                           28             55.
ST.A810707 2155   55   6   1.1   23               0.30
ST.A810708 1000   42  22                                                           27             75.
ST.A810708 2103   26   6   1.1   21               0.24
ST.A810709 0800   30   8   0.9   19   0.1   0.4    .23          5.7  2000   4  27   7.4   3.8 204
ST.A810710 0945   28   4                                                           27             41.
ST.A810713 1610   19   3                                                           27             16.
ST.A810715 0935   14   3                                                           28             12.
ST.A810716 1000   15   2   1.1   21   0.0   0.1    .11          5.4   300   5  28   8.2   5.4 206   11.
ST.A810720 1530   44  11                                                           26             35.
ST.A810721 1150   31   7                                                           27             31.
ST.A810722 1300   49  10                                                           26             47.
ST.A810723 1130  164  14
ST.A810724 1000   35   5                                                           23             30.
ST.A810730 0900   32   6   1.2  180  0.29  0.33    .33          4.0  3200   4  23   7.2   2.1 152   56.
ST.A810731 1110   18   1                                                           23             67.
ST.A810803 1540   21   4                                                           25             44.
ST.A810805 1525   24   6                                                           26             32.
ST.A810806 0915   21   6   1.1   22  0.03  0.02    .15          3.4   580   6  28   8.8   8.9 173   28.
ST.A810807 1025   16   6                                                           28             15.
ST.A810810 0945    1   3                                                           28             12.
ST.A810812 0940   12   5                                                           25             11.
ST.A810813 0900   16   6   1.0   19  0.06  0.03    .11                        5  25   7.8   5.5 185
ST.A810814 1040   22   4                                                           25             17.
ST.A810817 0925   13   4                                                           24             11.
ST.A810819 0945   10   3                                                           23             10.
ST.A810820 0840   14   5   0.8   18  0.03  0.01    .07                        5  23   7.9   1.3 204   10.
ST.A810821 1510   14   5                                                           23             11.
ST.A810824 0925   13   6                                                           24             7.7
ST.A810826 1430    7   2                                                           24             8.4
ST.A810827 0830    9   3   0.6   15   .02   .02    .05          4.8   190   4  24   8.1   6.2 203
ST.A810828 0945    9   3                                                           24             d.6
ST.A810831 0840    9   2
ST.A810720 1530    44  11                                                    26                 35.
ST.A810721 1150    31   7                                                    27                 31.
ST.A810722 1300    49  10                                                    26                 47.
ST.A810723 1130   164  14
ST.A810724 1000    35   5                                                    23                 30.
ST.A810730 0900    32   6  1.2  180  0.29 0.33   .33         4.0  3200    4  23  7.2  2.1 152   56.
ST.A810731 1110    18   1                                                    23                 67.
ST.A810803 1540    21   4                                                    25                 44.
ST.A810805 1525    24   6                                                    26                 32.
ST.A810806 0915    21   6  1.1   22  0.03 0.02   .15         3.4   580    6  28  8.8  8.9 173   28.
ST.A810807 1025    16   6                                                    28                 15.
ST.A810810 0945     3   3                                                    28                 12.
ST.A810812 0940    12   5                                                    25                 11.
ST.A810813 0900    16   6  1.0   19  0.06 0.03   .11                      5  25  7.8  5.5 185
ST.A810814 1040    22   4                                                    25                 17.
ST.A810817 0925    13   4                                                    24                 11.
ST.A810819 0945    10   3                                                    23                 10.
ST.A810820 0840    14   5  0.8   19  0.03 0.01   .07                      5  23  7.9  1.3 204   10.
ST.A810821 1510    14   5                                                    23                 11.
ST.A810824 0925    13   6                                                    24                 7.7
ST.A810826 1430     7   2                                                    24                 8.4
ST.A810827 0830     9   3  0.6   15   .02  .02   .05         4.8   190    4  24  8.1  6.2 203
ST.A810829 0945     9   3                                                    24                 8.6
ST.A810831 0840     9   2                                                    24                 7.6
ST.A810902 1130    19   6                                                    24                 11.
ST.A810903 0840    13   4  0.8   18    .1   .1  .059         4.9   670    6  24  7.8       210   10.
ST.A810904 0945    11   4                                                    22                 8.0
ST.A810907 1140    14   5                                                    23                 10.
ST.A810909 1000    20   4                                                    22                 12.
ST.A810910 0820    17   3  0.9   21   0.2  0.1   .05  .009   4.9  0.45    5  22  7.4  3.6 229   13.
ST.A810914 0910    14   7                                                    21
ST.A810916 1120    25   8                                                    20
ST.A810917 0900    20   8  1.1   24  0.63  0.1   .07         4.5  0.54    4  20  7.8  6.0 238
ST.A810918 1110    14   9                                                    19
ST.A810921 1320    13  10                                                    18
ST.A810923 1020    14   5                                                    18
ST.A810924 0830    20   6  1.0   22   0.1  0.1  .079         4.7  0.53    7  18  7.7  5.3
ST.A810925 0830    15   5                                                    20                  9.
ST.A810930 0940    14   4                                                    20                 5.2
ST.A811001 1010    24   7  0.8   19   0.0  0.1 0.065  .005   4.5  0.65    4  20  7.7  7.6 258   7.5
ST.A811002 0940    15   0                                                    18                 6.5
ST.A811006 1440    45   8                                                    18                 8.0
ST.A811007 1010    25   5                                                    17                 7.5
ST.A811008 0915    33   5  1.3   24   0.1  0.1  0.10  0.01   4.9  0.75    4  17  7.9  6.3 280   8.4
ST.A811009 0940    19   4                                                    17                 6.5
ST.A811014 1040    18   4                                                    17                 5.0
ST.A811015 0845                                                              17  7.5  6.9 301   5.0
ST.A811015 0845    18   3  1.0   16  0.15    0  0.07  0.02   5.0   560    4
ST.A811016 1050    16   3                                                    15
ST.A811019 1040    21   4                                                    13
ST.A811020 0910    19   4  0.9   16  0.10 0.14  0.09  0.03   5.3   620    6  13  7.7  7.9 301
ST.A811021 1000    15   4                                                    13                 11.
ST.A811026 1040    14   4                                                    13                 12.
ST.A811028 1125    16   6                                                    13                 12.
ST.A811029 0945                                                              13  8.1 10.0 288   11.
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ST.A811030 1040    19   1                                                    13                 9.5
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ST.A811104 1050    10   3                                                    13                 13.
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ST.A811106 0930    13   4                                                    13                 8.5
ST.A811109 1040    17   9                                                    12                 12.
ST.A811111 1310    19   6                                                    11                 15.
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ST.A811113 1420    17   3                                                    10                 16.
ST.A811116 1400    22   4                                                    11                 15.
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ST.A811123 0840    13   4                                                    10                 12.
ST.A811125 1020     9   4                                                     9                 8.2
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ST.A811202 1000    10   3                                                     7
ST.A811203 1000                                                               7  8.2 12.2 340
ST.A811203 1000     9   3  1.0   30  0.12 0.21  0.06   ...   5.2   300    4
ST.A811204 1010    20   6                                                     6                 14.
ST.A811207 0940     9   4                                                     7                 9.5
ST.A811209 1340    12   3                                                     5                 11.
ST.A811210 1000                                                               5  8.0 10.7 316   11.
ST.A811210 1000    11   2  0.7   21  0.15    0  0.05   ...   5.1   350    3
ST.A820315 1500     9   3
ST.A820317 1000    12   3
ST.A820318 0930    14   5  1.5        .71  .91   .18   .11   4.3   560    3
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ST.A820324 0945     7   1
ST.A820325 1000    16   4  1.6        .47  1.2   .16   .07   3.8   420    5
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ST.A811202 1000   10    3                                                                  ...
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ST.A811207 0940    9    4                                              6                 14.
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ST.A811210 1000                                                        5                 11.
ST.A811210 1000   11    2  0.7   21  0.15    0 0.05 ...   5.1  350    3    5  8.0 10.7  316  11.
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ST.B800503 1310  110   12
ST.B800504 1355   41   11
ST.B800505 1115   65   13
ST.B800506 1010   70   13                                                  18
ST.B800507 0905   26   12  1.8   26   0.5  1.3 0.22       5.1 1200        16
ST.B800507 0910   75   10
ST.B800508 1345   75    9                                                  19
ST.B800509 1015   22    4                                                  16
ST.B800510 0820  140   15                                                  15
ST.B800511 0920   65   10                                                  16
ST.B800512 1130   55    8                                                  17
ST.B800513 1425  430   38                                                  20
ST.B800514 1055  230   22  2.5   36   0.4  0.5 0.41       6.1 4100    9   17  7.8  7.5  345
ST.B800515 1420  140   13                                                  22
ST.B800516 1420  130   21                                                  17
ST.B800517 1425  270  100                                                  18
ST.B800518 1135  130   31                                                  16
ST.B800519 1500  190   23                                                  19
ST.B800520 1105   75    8                                                  19
ST.B800521 1030  120   15  2.2   28   0.5  1.6 0.32         5 3000    4   18  7.5  4.7  490
ST.B800522 0900  220   27                                                  20
ST.B800523 1033  130   18                                                  18
ST.B800524 0900  230   24                                                  18
ST.B800525 0900  210   21                                                  27
ST.B800526 0900  230   26                                                  28
ST.B800527 0900  290   26                                                  28
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ST.B800530 1420  300   14                                                  29
ST.B800531 0820   60    9                                                  22
ST.B800601 1300 4100  580                                                  19
ST.B800602 1410  230   26                                                  22
ST.B800603 1435  390   36                                                  27
ST.B800604 1340 2080  150
ST.B800605 0815  200   17  1.8   30   0.2  0.4 0.36       5.5 7830    4   21  7.3  5.5  295
ST.B800606 1105  110   10                                                  26
ST.B800609 1410  110   12                                                  26
ST.B800610 1005   44    6                                                  22
ST.B800611 0925   85   14
ST.B800611 0925   80    8  1.0   24   0.1  0.2            4.9 2700    6   24  7.4  9.4  305
ST.B800611 1435  200   14
ST.B800613 1020  110   11                                                  22
ST.B800614 1440   90   10
ST.B800615 1020   85   11
ST.B800616 1100   90   10
ST.B800617 0950   85   12                                                  20
ST.B800518 1000   46    8  0.7   24     0    0 0.15       4.8  950    6   23  8.0  5.3  325
ST.B800619 1755   28    8                                                  26
ST.B800620 1040   99    0                                                  22
ST.B800621 0900   50    0                                                  21
ST.B800622 1335   60    3                                                  28
ST.B800623 1015   93   12                                                  26
ST.B800624 1015   95    3                                                  23
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ST.B800626 1000   95   14                                                  26
ST.B800627 1410  120   15                                                  34
ST.B800628 1250   70    5                                                  35
ST.B800629 0850   50   10                                                  21
ST.B800630 1150   49   10                                                  29
ST.B800701 0940  110   11                                                  28
ST.B800702 0850  120   18  0.7   25   0.2    0 0.26      4.95 3400    3   29  7.5  2.2  330
ST.B800703 1015   60   10                                                  23
ST.B800704 1055   90    8                                                  29
ST.B800705 1025  120   15                                                  29
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ST.B800818 1020  100  15                                         27
ST.B800819 1220   41   7                                         32
ST.B800820 1055   49   6  1.0  24           0.18     4.6 1600  4 31  8.2  8.8 300
ST.B800821 1420   75   7                                         30
ST.B800822 1600   65  11                                         30
ST.B800823 1400   55   5                                         30
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ST.B800825 0925   50   0                                         26
ST.B800826 0920   60   6                                         27
ST.B800827 0910   60   2  1.1  24           0.17     4.5 1700  4 28       6.6 285
ST.B800828 0845   69  11                                         28
ST.B800829 1025   67  10                                         28
ST.B800830 0830   87  12                                         28
ST.B800831 1450   36  15                                         30
ST.B800901 1925   77  13                                         27
ST.B800902 1015   24   7                                         27
ST.B800903 0910   60   8  1.2  20           0.13     4.3 1400  5 23       5.1 300
ST.B800904 1415  120  14                                         26
ST.B800905 1535  390  36                                         26
ST.B800906 1015   55   8                                         27
ST.B800907 1010   80   9                                         26
ST.B800908 0950   43   9                                         26
ST.B800909 1030  210  18                                         27
ST.B800910 0935   55   9  1.6  23  0.4      0.20     4.9 1600  5 24  7.5  2.8 265
ST.B800911 1030   55   6                                         27
ST.B800912 1410   90   7                                         27
ST.B800913 0920   37   4                                         28
ST.B800914 1940   80   7                                         27
ST.B800915 1400   63   5                                         26
ST.B800916 0920   75   8                                         24
ST.B800917 0950   69   9  1.2  26  0.1  0.1 0.22     6.0 2100  7 21       6.2 260
ST.B800918 1455  130  28                                         26
ST.B800919 1445  160  26                                         25
ST.B800920 0910   57  10                                         23
ST.B800921 1040   47  13                                         25
ST.B800922 1020   66  12                                         27
ST.B800923 1520   40  10                                         21
ST.B800924 1335   76  13  1.3  25  0.1  0.1 0.19     5.5 1200  7 22      11.2 300
ST.B800925 1025   53   4                                         22
ST.B800926 1600   64   9                                         24
ST.B800927 1130   42   7                                         18
ST.B800928 1305   45   3                                         20
ST.B800929 1340   46   9                                         22
ST.B800930 1330   37   2                                         23
ST.B801001 0935   42   5  1.1  21  0.1  0.1 0.13     5.4 1100  5 20  8.3 10.6 295
ST.B801002 1100   48   9                                         18
ST.B801003 1010   34   3                                         15
ST.B801004 1235   33   4                                         15
ST.B801005 1620   30   3                                         18
ST.B801006 1415   90   5                                         18
ST.B801007 1055   50  12                                         16
ST.B801008 0945   65   8  1.5  25  0.1  0.1 0.22    4.88 1800  5 16  7.7  8.9 325
ST.B801009 1415   39   7                                         20
ST.B801010 1335   58   9                                         18
ST.B801011 1325   46  11                                         18
ST.B801012 1550   25   4                                         15
ST.B801013 1145   29   3                                         12
ST.B801014 1540   32   1                                         16
ST.B801015 0940   43   9  0.9  23  0.1  0.1 0.15     4.6 1810  5 13  7.7  8.0 325
ST.B801022 0950                                                  12  7.4  6.2 305
ST.B801029 0920   37   7  1.2  27  0.1  0.6 0.23     7.6 1300  5  6  7.5  9.7 410
ST.B801030 1020   17   4                                          7
ST.B801031 1500   34   6                                         13
ST.B801101 1005   41   8                                         14
ST.B801102 1340   44  13                                         14
ST.B801103 1005   45   5                                         10
ST.B801104 1110   43   8                                         10
ST.B801105 0920   45  12  1.4  27  0.1  0.2 0.21     7.3 1500  6  9  7.4  6.3 163
ST.B801106 0950   34   6                                         13
ST.B801107 1440   47   7                                         14
ST.B801108 1430  168  20                                         13
ST.B801109 1415   59   9                                         13
ST.B801110 0955   51   7                                         10
ST.B801111 0945   33   7                                          8
ST.B801112 1150   43   8  1.0  20  0.1  0.2 0.13     6.2 1300  5  8  7.8 11.4 340
ST.B801113 1105   28   4                                          9
ST.B801114 1035   46   7                                          9
ST.B801115 1225   25   5                                          7
ST.B801116 1100   24   4                                          6
ST.B801117 1150   14   4                                          5
ST.B801118 1020   12   3                                          4
ST.B801119 0925    8   2  0.6  16  0.1  0.3 0.06     5.0  210  3  4  7.9 12.8 338
ST.B801120 1405   51   6                                          8
ST.B801121 1005   15   3                                          5
ST.B801122 1110   17   3                                          5
ST.B801123 1245   20   4
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ST.8801117 1150    14    4                                               5
ST.8801118 1020    12    3                                               4
ST.8801119 0925     8    2   0.6  16  0.1  0.3  0.06     5.0   210   3   4   7.9 12.8 338
ST.8801120 1405    51    6                                               8
ST.8801121 1005    15    3                                               5
ST.8801122 1110    17    3                                               5
ST.8801123 1245    20    4                                               8
ST.8801124 1005    10    0   6.9  19  0.1  0.2  0.09     5.8   550   3   7   7.8 12.3 435
ST.8801125 1015    13    2                                               3
ST.8801126 1150     9    2                                               4
ST.8801127 1930     9    2                                               4
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ST.8801128 1410     8    1                                               5
ST.8801129 1430     0    0                                               6
ST.8801130 0900    22    2                                               6
ST.8801201 1440    18    5                                               8
ST.8801202 1100    23    4                                               3
ST.8801203 0925                                                          1   8.0 13.4 300
ST.8801204 1005    13    4                                               3
ST.8801205 1040    21    6                                               4
ST.8801206 1015    50    7                                               7
ST.8801207 0915    80   12                                              11
ST.8801208 1010   970  130                                               9
ST.8801209 0945   180   28                                               9
ST.8801210 1045                                                          3   7.7 12.1 565
ST.8801218 0950    10    2   0.6  14  0.1  1.0  0.10     4.7   900   3   2   7.7 13.2 500
ST.8810226 1330    38    6                                               8
ST.8810227 1015    75    7                                               7
ST.8810228 0930    65    7                                               6
ST.8810301 1830    65    7                                               5
ST.8810302 1155    55    5                                               8
ST.8810303 0935    18    2                                               5
ST.8810304 1110    19    2                                               6
ST.8810305 1050   220   23   5.4  82  1.5  2.4   1.5    11.6  7300  12   3   7.4      442
ST.8810306 30.0    45    4                                               6                  30.
ST.8810307 0845    28    7                                               2                  22.
ST.8810308 0920    24    4                                               2                  19.
ST.8810309 1100    17    3                                               4                  12.
ST.8810310 1345    55   11                                               4
ST.8810311 1020    55    7   1.1  19  0.1  1.5  0.19     3.7  2100   3   7   7.9      670   34.
ST.8810312 1115    31    4                                               8                  17.
ST.8810313 1045    55    6                                               7                  31.
ST.8810314 0825    20    3                                               5                  15.
ST.8810315 1930    47    7                                               7                  32.
ST.8810316 1045    45    7                                               8                  31.
ST.8810317 1000    32    4                                               8                  32.
ST.8810318 1020    47    8   0.9  17  0.1  0.8  0.15     3.4   1.8   4   7   7.8      600   30.
ST.8810319 1050    27    5                                               7                  31.
ST.8810320 1040    38    7                                               7                  25.
ST.8810321 0830    44    8                                               7                  32.
ST.8810322 0605    40    6                                               6                  26.
ST.8810323 0910    49    9                                               7                  30.
ST.8810324 1005    47    8                                              10                  33.
ST.8810325 1015    42    7   1.0  21  0.1  0.3  0.14     5.0  1300   3  10   8.0 10.5 469
ST.8810326 1505    90   11                                              10                  30.
ST.8810327 0950    55    8                                               9                  3.1
ST.8810328 0815   160   16                                              10                  32.
ST.8810329 1100   170   16                                               9                  33.
ST.8810330 1835   160   17                                               9                  35.
ST.8810331 1015   170   18                                              15                  33.
ST.8810401 0910   120   14   2.6  40  0.5  0.9  0.35     7.6   3.1   9  14   8.1 10.1 440   35.
ST.8810402 1020    90   14                                              14                  30.
ST.8810403 1420   110   16                                              12                  32.
ST.8810404 1505    55    8                                              14                  33.
ST.8810405 0900    37    4                                              14                  33.
ST.8810406 1150    36    6                                              14                  29.
ST.8810407 1100   130   13                                              15                  34.
ST.8810408 1350    95   12                                              14
ST.8810409 0945    34    8   1.3  27            0.13     5.6  1300   4  16   8.2  7.0 389
ST.8810410 1205   122   22                                              16                  32.
ST.8810411 1430   550   70                                              16                 390.
ST.8810412 0930   560   67                                              16                 385.
ST.8810413 1140   347   60                                              17                  275
ST.8810414 1430   230   35                                              17                  200
ST.8810415 1115  2010  152   2.3  44  0.4  2.7  0.56     6.0  7500   6  15   7.5  5.8 455  160.
ST.8810416 1025   161   19                                              15                   74
ST.8810417 1110   166   19                                              19                   94
ST.8810420 1240   151   18                                              18                   58
ST.8810421 1030    91   13                                              17                   44
ST.8810422 1350   256   27   2.3  42  0.3  3.4  0.60     5.0   540   5  16   7.6  6.7 440  170.
ST.8810423 1615   124   19                                              15
ST.8810424 1040    89   13                                              15
ST.8810425 1920   120   20                                              16
ST.8810426 1020   110   18                                              17
ST.8810427 1145    85   15                                              21
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ST.8810413 1140  347   60                                                     17                   275
ST.8810414 1430  230   35                                                     17                   200
ST.8810415 1115 2010  152  2.3   44  0.4  2.7  0.56         6.0 7500     6    15   7.5  5.8 455  160.
ST.8810416 1025  161   19                                                     15                    74
ST.8810417 1110  166   19                                                     19                    94
ST.8810420 1240  151   18                                                     18                    58
ST.8810421 1030   91   13                                                     17                    44
ST.8810422 1350  256   27  2.3   42  0.3  3.4  0.60         5.0  540     5    16   7.6  6.7 440  170.
ST.8810423 1615  124   19                                                     15
ST.8810424 1040   89   13                                                     15
ST.8810425 1920  120   20                                                     16
ST.8810426 1020  110   18                                                     17
ST.8810427 1145   85   15                                                     21
ST.8810428 1020  115   17                                                     20
ST.8810429 1035   63   11  2.0   22  0.6  3.3  0.24         4.1 1900     6
ST.8810430 1410  114   18                                                     22                   48.
ST.8810501 1145  102   12                                                     22                   47.
ST.8810502 0705  116   18                                                     19                   47.
ST.8810503 2005  108   12                                                     19                   44.
ST.8810504 1140  115   15
ST.8810505 1350   81   10                                                     19                   32.
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ST.8810507 1040   54    8                                                     20                   34.
ST.8810508 1020   85   13                                                     17                   46.
ST.8810510 0945  106   16                                                                          92.
ST.8810511 1025   96   16                                                     16                   90.
ST.8810512 1010   67    7                                                     16                   76.
ST.8810513 1035   79   11                                                     14                   49.
ST.8810514 0855  136   14  1.5   20  0.3  5.1  0.34         3.3 2500     5    14   7.4  5.6 628   63.
ST.8810515 1820   42    6                                                                          26.
ST.8810516 1250   81   10                                                                          40.
ST.8810517 1505   59    5                                                     14                   32.
ST.8810518 0820 1370  160  4.6   96            1.8
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ST.8810521 1040   88   12                                                     15                   55.
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ST.8810524 1625   97   10                                                     21                   55.
ST.8810525 0740   86    9                                                     23                   47.
ST.8810526 1120  109   17  4.6        0.0  1.2   .44         5.1 1800    38    23   8.6 17.0 406
ST.8810527 0910   85   16                                                     22                   35.
ST.8810528 0955   62    7                                                     24                   30.
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ST.8810530 0800   59    5                                                     21                   33.
ST.8810531 0900  126   10                                                     23                   60.
ST.8810601 1035  123   10                                                     23                   55.
ST.8810602 1020   62   10                                                     25                   33.
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ST.8810605 1030   95   14                                                     24                   39.
ST.8810608 1020  142   23                                                     23                   56.
ST.8810609 1040  102   19                                                     23                   59.
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ST.8810611 0915  102   14                                                     24                   43.
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ST.8810619 1355  740   80                                                     26                  360.
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ST.8810622 1110  800  100                                                     24
ST.8810622 2155  240   27  0.4   47                 0.83
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ST.8810627 0920  243   27                                                     25                  170.
ST.8810628 0705  106   18                                                     26                   67.
ST.8810629 1050  114   14                                                     26                   65.
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ST.BB10618 0840   131   18   1.5    34   0.0  0.1    .28        4.5 3100   7 24  8.5  7.7 300
ST.BB10619 1355   740   80                                                   26                 360.
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ST.BB10627 0920   243   27                                                   25                 170.
ST.BB10628 0705   106   18                                                   26                  67.
ST.BB10629 1050   114   14                                                   26                  65.
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ST.BB10701 1010    64    6                                                   28                  54.
ST.BB10702 1005    86   14                                                   29                  45.
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ST.BB10724 1010   130   22                                                   23                  72.
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ST.BB10828 0955    47    9                                                   23                  30.
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ST.BB10901 1010   170   22                                                   23                 120.
ST.BB10902 1140    50   11                                                   23                  42.
ST.BB10903 0900    36    7   1.3    29   0.1  0.1  0.089        5.3 1400   7 23  7.6      242    32.
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PB

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ST.8810831 0850    44    7                                                       24                     30.
ST.8810901 1010   170   22                                                       23                    120.
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ST.8810915 0940    52    8                                                       19
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ST.8810922 0920    41   15                                                       17
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ST.C810617 1005  102   10                                                          19                   40.
ST.C810618 0910   83    9  1.4   17 0.3  5.0   .36       4.3 1700     3 19  7.7  6.8 661
ST.C810619 1405  638   60                                                          20                  265.
ST.C810620 1115  156   16                                                          18                   84.
ST.C810621 0830 1700  160                                                          19
ST.C810621 221019200  760 21.0  490             5.5
ST.C810621 223515700  780 27.   635             6.1
ST.C810621 231010280  760 20.   465             4.9
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ST.C810623 1120   80    8                                                          21                   35.
ST.C810624 0550 7740  460 19.   385             4.3
ST.C810624 0620 5840  380  8.6  175             3.0
ST.C810624 0650 9790  650 14.   285             4.5
ST.C810624 0720 9740  630 17.   335             4.8
ST.C810624 220510530  670 26.   625             5.9
ST.C810624 233512500  610 19.   450             4.8
ST.C810624 240010500  620 20.   470             4.9
ST.C810625 0125 5140  360 11.   255             3.3
ST.C810625 1245  600   40                                                          22                  240.
ST.C810625 2450 6050  410 16.   345             4.1
ST.C810626 1055  376   38                                                          22                   56.
ST.C810627 1405   60    6                                                          22                   30.
ST.C810628 0715   52    4                                                          21                   27.
ST.C810629 1100   62    7                                                          22                   25.
ST.C810630 0840   50    7  1.4   15 0.5  4.5   .28       4.3      1.4  5 22  7.5  6.4 624
ST.C810702 1015   49    4                                                          23                   20.
ST.C810703 1530   28    4                                                          23                   10.
ST.C810704 1143 8770  450 13.   290             3.7
ST.C810704 1230 6210  260 10.   228             3.0
ST.C810704 1340 4290  200  6.6  142             2.3
ST.C810704 173015200  570 15.   360             3.7
ST.C810704 1425 8550  440 13.   280             3.1
ST.C810704 1900 5950  309  9.8                  2.6
ST.C810704 1945 3680  173  7.6  185             2.2
ST.C810705 1115  285   15                                                          22                  140.
ST.C810706 1025   98    2                                                          21                   45.
ST.C810707 1035   72    4                                                          20                   27.
ST.C810708 1430   90   16                                                          22                   32.
ST.C810709 0835  101   11  1.2   14 0.4  4.8   .27       4.0      0.8  3 22  7.6  6.6 605
ST.C810709 1530 3620   65  5.4  130             2.0
ST.C810709 180011700  480 12.   250             3.1
ST.C810710 1005   69    6                                                          23                   30.
ST.C810710 1020   50   10
ST.C810711 0825   58    2                                                          24                   25.
ST.C810713 1630   31    4                                                          23                   11.
ST.C810714 1005   49    3                                                          25                   16.
ST.C810715 0955  120    4                                                          26                   25.
ST.C810716 1045   48    2  1.1   13 0.3  0.9   .23       4.5 1000     7 26  7.2  5.4 641  21.
ST.C810720 1550  134   20                                                          25                   50.
ST.C810721 1210   75    8                                                          25                   27.
ST.C810722 1630   45    6                                                          24                   18.
ST.C810723 0930 1630  110       215
ST.C810723 1000 1150   97
ST.C810723 1050 2190  178
ST.C810724 1020   88   12                                                          21                   26.
ST.C810730 0940   57    9  0.9    8 0.17 4.5   .23       2.4 1800     4 21  7.2  6.8 255  22.
ST.C810731 1130   50    5                                                          21                   22.
ST.C810801 1010  276    4                                                          19                   14.
ST.C810802 1205   16    2                                                          20                   14.
ST.C810803 1600   32    4                                                          21                   19.
ST.C810804 0955   39    4                                                          20                   18.
ST.C810805 1545   22    4                                                          21                   10.
ST.C810806 0950   18    2  0.9   16 0.12 4.0   .15       2.6  590     2 22  7.5  6.4 646  10.
ST.C810807 1045   20    3                                                          20                   10.
ST.C810810 1035   33    6                                                          2                    14.
ST.C810811 1010   28    7                                                          24                   12.
ST.C810812 1030   26    6                                                          20                   10.
ST.C810412 100010000  440 18.0  420                4.6
ST.C810413 0100 7160  380
ST.C810413 0130 6130  330
ST.C810413 0200 5540  390
ST.C810413 0230 4000  300
ST.C810413 0300 3870  230
ST.C810413 0500 1730  150
ST.C810413 183021200  710 14.0  330                4.0
ST.C810413 1900 9110  430 16.0  305                4.2
ST.C810413 191519700  810 25.0  590                6.0
ST.C810413 193023400 1130 40.0  840                7.8
ST.C810413 194523800 1080 43.0  970                8.7
ST.C810413 200019700 1070 31.0  665                6.9
ST.C810413 201513200  740 33.0  705                7.4
ST.C810414 1440  365   50                                       15                 125
ST.C810415 1130  138   10  1.4   20  0.3  6.0 0.32      3.4 3300   3 12  7.5  9.2 643  57.
ST.C810416 1035   77    9                                       12                  29
ST.C810417 1120   85    9                                       13                  34
ST.C810420 1250   51    6                                       13                  18
ST.C810421 1040   30    5                                       13                  12
ST.C810422 1410 1407  153  7.1  141  0.7  3.0  1.9      9.6 3000  20 15  7.5  7.1 433 320.
ST.C810423 1625  104   12                                       12
ST.C810424 1050   98   10                                       12
ST.C810425 1930   87   13                                       14
ST.C810426 1030   98   13                                       16
ST.C810427 1155   97   13                                       18
ST.C810428 1030  100   14                                       17
ST.C810429 1050   64    9  1.1   17  0.2  4.4 0.20      2.8 1400   4
ST.C810430 1420   71   11                                       18                 26.
ST.C810501 1155   46    8                                       18                 20.
ST.C810502 0715   93   12                                       15                 33.
ST.C810503 2015   95   14                                       15                 34.
ST.C810504 1150   95    7
ST.C810505 1400   57    3                                       15                 26.
ST.C810506 1110   25    2  0.7   10  0.1  3.9 0.14      2.3  700   2 13  7.8  9.9 656
ST.C810507 1050   28    5                                       15                 14.
ST.C810508 1030   37    5                                       14                 19.
ST.C810509 1320   38   11
ST.C810509 1330   38    5                                       12                 17.
ST.C810510 0800 1910  150  6.2  137                2.0
ST.C810510 0830 3640  293  8.1  168                2.4
ST.C810510 0900 2460  245  9.0  192                2.8
ST.C810510 0930 2670 1310  8.8  168                2.8
ST.C810510 1030 2650  227  8.9  180                2.9
ST.C810511 1130  123   14                                       12                 64.
ST.C810512 1020   49    6                                       12                 30.
ST.C810513 1045   58    6                                       11                 25.
ST.C810514 0920  125   14  1.3   17  0.2  5.6 0.28      3.0 2200   3 12  7.6 D8.6 661  53.
ST.C810515 1930   73    9                                                          30.
ST.C810516 1320   79    9                                                          30.
ST.C810517 1515   99   12                                                          39.
ST.C810518 0600 5848  328  9.5  220                3.1
ST.C810518 0645 4873  320  9.2  220                3.1
ST.C810518 0800 3600  260  5.9  131                2.0
ST.C810518 0900 3670  220  5.9  135                2.2
ST.C810518 1015 3300  180  5.4  123                2.0
ST.C810519 1345  210   24  1.5   21               0.39                      13                 71.
ST.C810520 1040   80   14  1.3   15  0.2  5.7 0.30      3.0 2400   4 11  7.5  9.2 585  45.
ST.C810521 1050   73    6                                       14                 30.
ST.C810522 1005   63    5                                       15                 25.
ST.C810523 1420  175   14                                       17                 59.
ST.C810524 1635  130   11                                       17                 52.
ST.C810525 0750   92    9                                       17                 38.
ST.C810526 1135   99    6  1.1   10  0.1  6.0  .22      2.7 1700   5 17  7.5  8.0 670
ST.C810527 0920   76    7                                       17                 44.
ST.C810528 1005   98    5                                       18                 44.
ST.C810529 1055   92    4                                       17                 39.
ST.C810530 0810   75    6                                       18                 32.
ST.C810531 0910  141    8                                       19                 45.
ST.C810601 1045  146   10                                       19                 40.
ST.C810602 1030   86    9                                       19                 40.
ST.C810603 1035  107    8  1.0   14  0.0  5.5  .20      2.3 1700   5 19  7.5 D7.4 696
ST.C810604 1100  104   10                                       20                 38.
ST.C810605 1040  105   12                                       21                 40.
ST.C810608 1030  118   15                                       19                 42.
ST.C810609 1050  104   14                                       20                 42.
ST.C810610 1020   99   14  1.1   12  0.1  0.1  .24      2.5 2200   5 21  7.6  6.1 708  41.
ST.C810611 0925   83   14                                       21                 34.
ST.C810612 1020  143   20                                       20                 46.
ST.C810613 1710   85   13                                       21                 32.
ST.C810614 1030   96   10                                       19                 32.
ST.C810615 1050   90    5                                       21                 31.
ST.C810615 185547200 1840  56. 1350                8.4
ST.C810615 193019500 1290 27.0  603                7.8
ST.C810615 195516600 1043 19.   413                5.3
ST.C810615 202014700  980  24.  550                6.4
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ST.C801208 1030  790   90
ST.C801209 1000   38    9                                                      8
ST.C801210 1110                                                                2  7.8 14.8 690
ST.C801218 1020    5    1   0.5     9   0.1  1.5   .09         2.7  500    2   .  7.8 14.4 650
ST.C810226 1340   10    2                                                      7
ST.C810227 1025    9    2                                                      7
ST.C810228 0940   11    1                                                      5
ST.C810301 1840   12    2                                                      5
ST.C810302 1505    5    1                                                      6
ST.C810303 0945    5    0                                                      2
ST.C810304 1120   10    1                                                      4
ST.C810304 2230 3230  175   7.9   190              2.2
ST.C810304 2300 3600  210   9.1   240              2.8
ST.C810304 2330 2800  200   16.   330              4.0
ST.C810304 2400 2700  220   18.   345              4.9
ST.C810305 0100 2200  220   16.   275              3.9
ST.C810305 0130 1800  170   14.   270              3.8
ST.C810305 0200 1600  170   13.   250              3.7
ST.C810305 0230 1300  160   15.   235              3.5
ST.C810305 1110  220   24   3.5    50   1.0  3.2  0.90         8.0 4300    9   3  7.7      541
ST.C810306 0030 2100  230   15.   305              4.4
ST.C810306 1440   24    2                                                      4                 13.
ST.C810307 0855   22    6                                                      2                 11.
ST.C810308 0930   12    4                                                      2                 7.2
ST.C810309 1050    8    0                                                      3                 4.5
ST.C810310 1355    7    1                                                      3
ST.C810311 1035    7    3   0.6    12        2.2  0.08         2.6  500    2   5  7.6      640   5.8
ST.C810312 1120    7    1                                                      7                 5.6
ST.C810313 1055    9    1                                                      6                  6.
ST.C810314 0835   10    1                                                      6                 6.7
ST.C810315 1940    8    2                                                      6                 5.8
ST.C810316 1055    7    1                                                      6                 5.5
ST.C810317 1010   11    3                                                      7                 5.6
ST.C810318 1045    9    2   0.7    12   0.0  1.6  0.07         2.3  0.7    3   5  7.6      650   5.3
ST.C810319 1100   11    3                                                      5                 5.2
ST.C810320 1050    9    3                                                      6                 5.5
ST.C810321 0840   14    3                                                      6                 8.5
ST.C810322 0615   13    3                                                      5                  6.
ST.C810323 0920   15    4                                                      6                 5.5
ST.C810324 1015   10    2                                                      7                 5.1
ST.C810325 1030   11    2   0.8    17   0.0  1.3  0.09         2.6  900    3   7  8.0 12.1 540
ST.C810326 1515   12    2                                                      7                  6.
ST.C810327 1000   10    2                                                      7                 5.6
ST.C810328 0825   25    4                                                      9                 5.8
ST.C810329 1110   15    2                                                      8                 5.9
ST.C810330 1845   15    3                                                      8                 6.1
ST.C810331 1025   18    4                                                     10                 5.9
ST.C810401 0930   24    3   0.8    17   0.1  1.1  0.15         4.1  1.1    4  11  7.8 10.7 552   6.1
ST.C810402 1030   14    4                                                     11                 5.9
ST.C810403 1430   25    3                                                     12                 5.7
ST.C810404 1515   17    4                                                     11                 5.5
ST.C810405 0910    7    2                                                     10                 5.5
ST.C810406 1200    7    2                                                     11                 5.1
ST.C810407 1340   11    2                                                     12                 5.1
ST.C810408 1400   14    2                                                     13
ST.C810409 1000   18    4   1.0    18   0.1  1.3  0.13         2.7  800    3  13  7.7  9.9 684
ST.C810410 1215   26   10                                                     14                 5.8
ST.C810411 0615 7210  530  15.0   345              6.0
ST.C810411 0645 7160  500  13.0   345              5.2
ST.C810411 0715 6000  480  12.0   290              4.7
ST.C810411 0745  210  190  12.0   290              3.7
ST.C810411 0815 3540  330  12.0   260              3.5
ST.C810411 0845 1873  187   7.2   155              2.4
ST.C810412 0530 8960  410  13.0   330              3.9
ST.C810412 0630 6050  460   9.3   200              3.0
ST.C810412 073012500  590  13.0   305              3.8
ST.C810412 083012700  850  20.0   425              5.6
ST.C810412 100010000  440  18.0   420              4.6
ST.C810413 0100 7160  380
ST.C810413 0130 6130  330
ST.C810413 0200 5540  390
ST.C810413 0230 4000  300
ST.C810413 0300 3870  230
ST.C810413 0500 1730  150
ST.C810413 183021200  710  14.0   330              4.0
ST.C810413 1900 9110  430  16.0   305              4.2
ST.C810413 191519700  810  25.0   590              6.0
ST.C810413 193023400 1130  40.0   840              7.8
ST.C810413 194523800 1080  43.0   970              8.7
ST.C810413 200019700 1070  31.0   665              6.9
ST.C810413 201513200  740  33.0   705              7.4
ST.C810414 1440  365   50                                                     15                 125
ST.C810415 1130  138   10   1.4    20   0.3  6.0  0.32         3.4 3300    3  12  7.5  9.2 641   57.
ST.C810416 1035   77    9                                                     12                  29
ST.C810417 1120   85    9                                                     13                  34
ST.C810420 1250   51    6                                                     13                  18
ST.C800925 1035   17    0
ST.C800926 1610   10    1                                                     17
ST.C800927 1140   67    3                                                     14
ST.C800928 1315   10    2                                                     13
ST.C800929 1350    6    1                                                     15
ST.C800930 1340    4    0                                                     13
ST.C801001 0950   10    2   1.2   21  0.1   0.1 0.16                          16
ST.C801002 1110    4    2                                6.5  560     9       15  7.5 11.2 655
ST.C801003 1020    6    2                                                     14
ST.C801004 1245    4    1                                                     12
ST.C801005 1630    7    2                                                     11
ST.C801006 1425    4    2                                                     11
ST.C801007 1105   16    6                                                     11
ST.C801008 1005    6    3   0.6   18  0.1   0.1 0.12                          11
ST.C801009 1455   16    2                                4.77 520     3       12  7.5  8.2 600
ST.C801010 1350    8    1                                                     15
ST.C801011 1335   15    3                                                     14
ST.C801012 1630    8    1                                                     14
ST.C801013 1155    6    2                                                     10
ST.C801014 1550    7    2                                                      8
ST.C801015 1000   13    2   1.0   21  0.1   0.1 0.19                          12
ST.C801022 1010                                          5.2  930     5       10  7.5  5.3 680
ST.C801029 0940   50    8   1.8   40  0.1   0.4 0.54                          11  7.5  8.5 530
ST.C801030 1030   28    5                               11.0 1600     7        4  7.6 11.1 580
ST.C801031 1505   19    5                                                      3
ST.C801101 0955   12    2                                                      7
ST.C801102 1200   11    2                                                      8
ST.C801103 1010    9    3                                                      8
ST.C801104 1120    9    4                                                      8
ST.C801105 0945    8    2   0.7   17  0.1   0.4 0.15                           8
ST.C801106 1400   10    7                                7.0  620     3        7  7.7 10.1 700
ST.C801107 1410    8    6                                                      8
ST.C801108 1440   33    5                                                     10
ST.C801109 1425   13    5                                                     11
ST.C801110 1005   12    3                                                     11
ST.C801111 0955   13    1                                                      7
ST.C801112 1215    7    3   0.7   13  0.1   0.1 0.10                           5
ST.C801113 1115    6    1                                5.9  500     3        7  7.7 13.7 660
ST.C801114 1025   11    3                                                      8
ST.C801115 1215    7    3                                                      7
ST.C801116 1050    6    2                                                      6
ST.C801117 1105    6    2                                                      4
ST.C801118 1010    6    2                                                      3
ST.C801119 0945    3    1   0.6   13  0.1   0.2 0.09                           2
ST.C801120 1355    8    3                                4.5  570     3        2  7.9 13.9 760
ST.C801121 1010    3    1                                                      3
ST.C801122 1100    3    1                                                      2
ST.C801123 1235    4    2                                                      3
ST.C801124 1030    5    2   0.5   14  0.4   0.5 0.08                           5
ST.C801125 1005    4    0                                4.1  480     2        5  7.8 13.2 675
ST.C801126 1200    4    2                                                      2
ST.C801127 1940    2    1                                                      1
ST.C801128 1420   10    1                                                      2
ST.C801129 1440    2    0                                                      3
ST.C801130 0910    2    0                                                      3
ST.C801201 1425   11    2                                                      3
ST.C801202 1110    9    2                                                      3
ST.C801203 0950                                                                2
ST.C801204 1015    5    2                                                      1  7.8 14.6 650
ST.C801205 1050    5    2                                                      1
ST.C801206 1025    5    2                                                      2
ST.C801207 0900  570   50                                                      3
ST.C801208 1030  790   90                                                     11
ST.C801209 1000   38    9
ST.C801210 1110                                                                8
ST.C801218 1020    5    1   0.5    9  0.1   1.5  .09                           2  7.8 14.8 690
ST.C810226 1340   10    2                                2.7  500     2        2  7.8 14.4 650
ST.C810227 1025    9    2                                                      7
ST.C810228 0940   11    1                                                      7
ST.C810301 1840   12    2                                                      5
ST.C810302 1505    5    1                                                      5
ST.C810303 0945    5    0                                                      6
ST.C810304 1120   10    1                                                      2
ST.C810304 2230 3230  175   7.9  190            2.2                            4
ST.C810304 2300 3600  210   9.1  240            2.8
ST.C810304 2330 2800  200  16.   330            4.0
ST.C810304 2400 2700  220  18.   345            4.9
ST.C810305 0100 2200  220  16.   275            3.9
ST.C810305 0130 1800  170  14.   270            3.8
ST.C810305 0200 1600  170  13.   250            3.7
ST.C810305 0230 1300  160  15.   235            3.5
ST.C810305 1110  220   24   3.5   50  1.0  1.2  0.90
ST.C810306 0030 2100  230  15.   305            4.4      8.0 4300     9        3  7.7      541
ST.C810306 1440   24    2
ST.C810307 0955   22    6                                                      4        13.
                                                                               2        11.
                                                                               2        7.2
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ST.C800824 1025
ST.C800825 0935   75    6                                                   20
ST.C800826 0930   47    0                                                   20
ST.C800827 0925   45    9  1.3   26  0.1  0.9  0.24       7.9 1600     6    21          4.5 455
ST.C800828 0900   28    7                                                   22
ST.C800829 1035   27    5                                                   22
ST.C800830 0850   17    6                                                   22
ST.C800831 1530   73   15                                                   22
ST.C800901 1935   31    7                                                   23
ST.C800902 1035  360   52                                                   23
ST.C800903 0930  120   22  3.0   56  0.2  1.0  0.71       8.4 3400    18    21          6.6 420
ST.C800904 0740 4240  400
ST.C800904 0800 6470  350
ST.C800904 0820 2050  140
ST.C800904 0850   DISCARDED BEFORE ANALYSIS
ST.C800905 0850 6100  300
ST.C800905 0905 6260  340
ST.C800905 0915 3790  180
ST.C800905 0925 3630  170
ST.C800905 0935 2580  210
ST.C800905 0945 5320  300
ST.C800905 1000 3690  240
ST.C800905 1015 5030  310
ST.C800905 1030 2760  210
ST.C800905 1045 2450  210
ST.C800905 1100 3460  300
ST.C800905 1115 1780  140
ST.C800905 1130 4040  260
ST.C800905 1145 4170  310
ST.C800905 1215 3450  260
ST.C800905 1230 2790  230
ST.C800905 1245 2370  200
ST.C800905 1300 2470  230
ST.C800905 1315 1680  100
ST.C800905 1330 1990  160
ST.C800905 1345 1260  110
ST.C800906 1025  160   20                                                   21
ST.C800907 1020  640   70                                                   21
ST.C800908 1000  200   26                                                   21
ST.C800909 1040   90   12                                                   24
ST.C800910 1000   85   15  3.8   32  2.1  0.6  0.40       8.9 3000    15    20  6.5   6.0 420
ST.C800911 1045   92    9                                                   23
ST.C800912 1430   42    7                                                   24
ST.C800913 0930   61    7                                                   23
ST.C800915 1430   36    5                                                   23
ST.C800916 0930  230   25                                                   20
ST.C800916 1835 4340  250
ST.C800916 1845 3860  160
ST.C800916 1855 5430  170
ST.C800916 1910   59    3
ST.C800916 1930 3990  280
ST.C800916 1945 2350  120
ST.C800916 2000 3670  170
ST.C800916 2035 1480  150
ST.C800916 2100 2490  170
ST.C800916 2130 1650  120
ST.C800916 2200 2530  160
ST.C800917 1020  210   22  2.9   50  0.8  1.4  1.1       12.  9000    13    15          7.9 315
ST.C800918 1505  130   27                                                   19
ST.C800919 1455   33    5                                                   20
ST.C800920 0925   33    6                                                   19
ST.C800921 1055   27    8                                                   22
ST.C800922 1115   25    6                                                   23
ST.C800923 1530   17    1                                                   17
ST.C800924 1350   19    4  1.2   22  0.1  0.9 0.17        7.4  700     6    16         12.0 610
ST.C800925 1035   17    0                                                   17
ST.C800926 1610   10    1                                                   14
ST.C800927 1140   67    3                                                   13
ST.C800928 1315   10    2                                                   15
ST.C800929 1350    6    1                                                   13
ST.C800930 1340    4    0                                                   16
ST.C801001 0950   10    2  1.2   21  0.1  0.1 0.16        6.5  560     9    15  7.5  11.2 655
ST.C801002 1110    4    2                                                   14
ST.C801003 1020    6    2                                                   12
ST.C801004 1245    4    1                                                   11
ST.C801005 1630    7    2                                                   11
ST.C801006 1425    4    2                                                   11
ST.C801007 1105   16    6                                                   11
ST.C801008 1005    6    3  0.6   18  0.1  0.1 0.12        4.77  520     3    12  7.5   8.2 600
ST.C801009 1455   16    2                                                   15
ST.C801010 1350    8    1                                                   14
ST.C801011 1335   15    3                                                   14
ST.C801012 1630    8    1                                                   10
ST.C801013 1155    6    2                                                    8
ST.C801014 1550    7    2                                                   12
ST.C801015 1000   13    2  1.0   21  0.1  0.1 0.19        5.2  930     5    10  7.5   5.3 680
                                                                            11  7.5   8.5 530
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ST.C800711 1135   40    1                                                26
ST.C800712 1435   32    5                                                27
ST.C800713 1620   28    7                                                31
ST.C800714 1540   29    4                                                30
ST.C800715 1545   22    1                                                31
ST.C800716 0945   40    4                                                30
ST.C800717 1020   26    0  0.7   16    0  1.2  .20     5.111300    3  27        6.0 550
ST.C800718 1510   28    1                                                24
ST.C800719 1315   26    4                                                27
ST.C800720 1515   10    1                                                29
ST.C800721 1025   55   13                                                30
ST.C800722 1455   41    3                                                27
ST.C800723 1055   43    8                                                27
ST.C800724 1045   25    7  1.0   25    0    0  .24     6.7 1290    4  22  9.6  9.1 560
ST.C800725 1135   28    6                                                25
ST.C800726 1250   38   11                                                26
ST.C800727 1740   27    5                                                22
ST.C800728 1430   21    5                                                21
ST.C800729 1045   22    4
ST.C800730 1020   30    7                                                22
ST.C800801 1120   55   22  0.9   19  0.2    0  0.2     3.1 1700    4  22        7.2 625
ST.C800802 1515   50   23                                                24
ST.C800803 1240   45   15                                                26
ST.C800804 1035   75   19                                                24
ST.C800804 202012670 9130                                                22
ST.C800805 1415  340   50
ST.C800806 1050  700  110                                                25
ST.C800807 1845  122   15  5.3  121  1.1  1.5  2.1     21.  39000   16  23  7.3  5.3 290
ST.C800808 1030  104   11                                                28
ST.C800810 1015   83    9                                                25
ST.C800811 1010   78   14                                                26
ST.C800812 1050   97   32                                                24
ST.C800813 1005  150   26                                                23
ST.C800814 1535  130   23  2.6   68  0.2    0  .38       10 5700    6  22        4.8 385
ST.C800815 075513000  530                                                25
ST.C800815 0810 6900  360
ST.C800815 0830 4300  230
ST.C800815 0850 2200  130
ST.C800815 0905 1500   80
ST.C800815 0925 4000  210
ST.C800815 0945 3000  190
ST.C800815 1000 3000  200
ST.C800815 1025 3500  270
ST.C800815 1100 2900  160
ST.C800815 1330 2000  240
ST.C800815 1435 1700  180
ST.C800816 0555 3500  210
ST.C800816 0625 4900  320
ST.C800816 0650 5500  290
ST.C800816 0700 4200  240
ST.C800816 0750 3200  200
ST.C800816 0815 3900  300
ST.C800816 0825 4300  340
ST.C800816 0908 2700  210
ST.C800816 0925 2000  160
ST.C800816 1105 1500  130
ST.C800816 1215 1300  100
ST.C800816 1805 8500  360
ST.C800816 1820 5400  230
ST.C800816 1837 3500  190
ST.C800816 1853 4600  210
ST.C800816 1905 4100  210
ST.C800816 1920 4900  360
ST.C800816 1950 4200  210
ST.C800816 2020 2900  190
ST.C800816 2120 2200  210
ST.C800816 2200 2900  200
ST.C800816 2230 2200  140
ST.C800817 1125  430   55
ST.C800819 0800  210   26                                                24
ST.C800819 1215  210   14                                                24
ST.C800820 1205  150   11                                                26
ST.C800821 1450  510   40  2.4   38  0.9  0.8 0.48     10.5 4400   12  26  5.7  5.5 480
ST.C800822 1625                                                          25
ST.C800823 1410   70    8                                                25
ST.C800824 1025   95    5                                                25
ST.C800824 1025   95    5                                                21
ST.C800825 0935   75    6
ST.C800826 0930   47    0                                                20
ST.C800827 0925   45    9                                                20
ST.C800828 0900   28    7  1.3   26  0.1  0.9 0.24      7.9 1600    6  21        4.5 455
ST.C800829 1035   27    5                                                22
ST.C800830 0850   17    6                                                22
ST.C800831 1530   73   15                                                22
ST.C800901 1935   31    7                                                22
ST.C800902 1015  360   52                                                23
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ST.C800526 0900   70   10
ST.C800527 0900   70    4                                                23
ST.C800528 0930   95   11                                                23
ST.C800529 0940  100   14   1.3   13  0.1  3.3  .22       2.6 1700    5  22  6.5  8.0 620
ST.C800529 1520   65    6                                                24
ST.C800530 0810  200   17
ST.C800530 0910 2310  110
ST.C800530 1410  110   11                                                26
ST.C800531 0805   80    6                                                19
ST.C800531 2245 6240  400
ST.C800601 073576000 2250
ST.C800601 074537000 1720
ST.C800601 080053000 2150
ST.C800601 085031000 1250
ST.C800601 090530000 1400
ST.C800601 094526100 1550
ST.C800601 102518200 1150
ST.C800601 113012450  750
ST.C800601 1400 4675  350
ST.C800602 1430  155   16                                                18
ST.C800603 0015 8150  450
ST.C800603 012518050  900
ST.C800603 021011080  780
ST.C800603 030010030  750
ST.C800603 1450  320   33                                                24
ST.C800604 0930 2090  170
ST.C800604 102524300 1250
ST.C800604 105515000  950
ST.C800604 114512730  650
ST.C800605 0830  140   12   1.5   23  0.3  4.3  .42       4.1 4900    6  17  7.3  9.9 510
ST.C800606 1130  100    4                                                20
ST.C800609 1425   55    3                                                20
ST.C800610 1015  100    5                                                18
ST.C800611 1000   95   11
ST.C800611 1000   90    6   0.6   11  0.1  4.4            2.0 2500    3  16  8.2  9.9 520
ST.C800612 1445   30    1                                                20
ST.C800613 1005                                                          22       4.8 385
ST.C800613 1030   39    4                                                18
ST.C800614 1455   65    5
ST.C800615 1030   50    4
ST.C800616 1115   43    3
ST.C800617 1135   36    2                                                18
ST.C800618 0800   95    7   0.7   11  0.1  3.9  .18       1.8 1400    4  17  7.2  8.2 610
ST.C800619 1805   19    3                                                21
ST.C800620 1115   35    3                                                21
ST.C800621 0915   46    2                                                17
ST.C800622 1845   34    8                                                23
ST.C800623 1030   45    5                                                24
ST.C800624 1000   91    3                                                20
ST.C800625 0830   75    8   0.7   15  0.1  3.0  .21       3.5 1240    3  20  6.8  8.1 560
ST.C800626 1030   38    4                                                21
ST.C800627 1420   44    7                                                28
ST.C800628 1300   37    5                                                28
ST.C800629 0900   45    9
ST.C800630 1200   38    6                                                22
ST.C800701 0950   50    8                                                23
ST.C800702 0930   49    6   0.6   13  0.1  2.4  .21      1.95 1400    3  24  7.7  5.8 565
ST.C800703 0905  120    8                                                19
ST.C800704 1105   95    9                                                24
ST.C800705 1035  110   19                                                25
ST.C800706 1325  110   20                                                24
ST.C800707 1210   60   14                                                27
ST.C800708 0905   49   14                                                26
ST.C800709 0920   80    9   1.2   17  0.2  2.4  .29       4.4 2900    3  26       5.7 525
ST.C800710 1020   49    4                                                26
ST.C800711 1135   40    1                                                27
ST.C800712 1435   32    5                                                31
ST.C800713 1620   28    7                                                30
ST.C800714 1540   29    4                                                31
ST.C800715 1545   22    1                                                30
ST.C800716 0945   40    4   0.7   16    0  1.2  .20       5.111300    3  27       6.0 550
ST.C800717 1020   26    0                                                24
ST.C800718 1510   28    1                                                27
ST.C800719 1315   26    4                                                29
ST.C800720 1515   10    1                                                30
ST.C800721 1025   55   13                                                27
ST.C800722 1455   41    3                                                27
ST.C800723 1055   43    8   1.0   25    0    0  .24       6.7 1290    4  22  9.6  9.1 560
ST.C800724 1045   25    7                                                25
ST.C800725 1135   28    6                                                26
ST.C800726 1250   38   11                                                22
ST.C800727 1740   27    5                                                21
ST.C800728 1430   21    5
ST.C800729 1045   22    4                                                22
ST.C800730 1020   10    7   0.9   19  0.2    0  0.2       3.1 1700    4  22       7.2 625
ST.C800801 1120   55   22                                                24
ST.C810716 1045    48     2  1.1   13    0.3   0.9  .23           4.5   1000        7  26  7.2  5.4  641  21.
ST.C810720 1550   134    20                                                            25                 50.
ST.C810721 1210    75     8                                                            25                 27.
ST.C810722 1600    45     6                                                            24                 18.
ST.C810723 0930  1630   110        215
ST.C810723 1000  1150    97
ST.C810723 1050  2180   178
ST.C810724 1020    88    12                                                            21                 26.
ST.C810730 0940    57     9  0.9   8     0.17  4.5  .23           2.4   1800        4  21  7.2  6.8  255  22.
ST.C810731 1130    50     5                                                            21                 22.
ST.C810801 1010   276     4                                                            19                 14.
ST.C810802 1205    16     2                                                            20                 14.
ST.C810803 1600    32     4                                                            21                 19.
ST.C810804 0955    39     4                                                            20                 18.
ST.C810805 1545    22     4                                                            21                 10.
ST.C810806 0950    18     2  0.9   16    0.12  4.0  .15           2.6   590         2  22  7.5  6.4  646  10.
ST.C810807 1045    20     3                                                            20                 10.
ST.C810810 1005    33     6                                                            22                 14.
ST.C810811 1010    28     7                                                            24                 12.
ST.C810812 1000    26     6                                                            20                 10.
ST.C810813 0940    27     6  0.7   10    0.07  3.6  .15                              4  20  7.6  8.1  695
ST.C810814 1100    31     3                                                            19                 12.
ST.C810815 0810    43     6                                                            21                 27.
ST.C810816 1500    42     5                                                            19                 28.
ST.C810817 0945    49     5                                                            17                 26.
ST.C810818 1000    29     2                                                            18                 18.
ST.C810819 1005    32     3                                                            18                 17.
ST.C810820 0920    25     3  .7    10    0.10  3.3  0.15                             3  18  7.6       646  14.
ST.C810821 1530    14     5                                                            19                 8.1
ST.C810822 0755    17     5                                                            20                 11.
ST.C810823 1430    17     4                                                            19                 10.
ST.C810824 0945    21     4                                                            21                 13.
ST.C810825 1520    15     3                                                            20                 10.
ST.C810926 1450    14     3                                                            21                 11.
ST.C810827 0910    31     5  .6    11    0.07  2.4  0.147         3.6   570         5  21  7.5  9.1  632
ST.C810828 1005    23     3                                                            20                 14.
ST.C810829 1610    21     4                                                            19                 13.
ST.C810830 1200    21     3                                                            17                 12.
ST.C810831 0900    50     7                                                            18                 29.
ST.C810901 1020   246    35                                                            18                 240.
ST.C810902 1150    70     9                                                            19                 47.
ST.C810903 0920    64     7  1.2   17    0.1   2.2  0.215         5.1   1700        5  19  7.5       609  34.
ST.C810904 1005    45     6                                                            17                 24.
ST.C810907 1200    40     6                                                            18                 21.
ST.C810908 1030    42     5                                                            17                 25.
ST.C810909 1020    39     4                                                            18                 20.
ST.C810910 0920    43     4  1.0   17    0.17  1.7  .17    .109   4.0         1.18  3  18  7.6  5.6  636  20.
ST.C810914 0930    36     7                                                            16
ST.C810915 0955    17     3                                                            17
ST.C810916 1145    26     4                                                            15
ST.C810917 0940    19     5  0.8   21    0.12  1.4  .14           3.5         0.58     15  7.9  7.4
ST.C810918 1130     9     5                                                            14
ST.C810921 1340    21     6                                                            15
ST.C810922 0930    18     3                                                            14
ST.C810923 1050    22     4                                                            15
ST.C810924 0920    24     3  0.7   15    0.15  1.2  0.123         3.3         0.72  6  15  7.2  6.9
ST.C810925 0850    16     2                                                            16                 5.5
ST.C810929 0950    13     1                                                            16                 6.5
ST.C810930 1000    24     5                                                            17                 7.5
ST.C811001 1110    23     5  0.8   17    0.0   0.0  0.1570.083    3.1         0.83  5  17  7.7  6.4  666  8.0
ST.C811002 1030    22     3                                                            14                 6.2
ST.C811005 0535  4360   213  7.2   180               2.2
ST.C811005 061014300    747  19.0  490               4.6
ST.C811005 0640  9470   470  17.0  370               5.0
ST.C811005 0710  6170   330  11.0  420               3.7
ST.C811005 0810  4220   250  10.0  240               3.2
ST.C811006 1500    88     9                                                            11                 23.
ST.C811007 1030    38     5                                                            11                 10.
ST.C811008 1000    23     2  0.9   18    0.10  2.0  0.23   0.15   7.3         0.81  3  11  7.6  7.6  603  5.5
ST.C811009 1000    18     3                                                            13                 5.0
ST.C811014 1100   940   124                                                            13                 82.
ST.C811015 0935   136    22  2.0   43    0.10  1.4  0.70   0.47   11.0              7  13  7.7  6.5  513  38.
ST.C811016 1110    34     5                                                            11
ST.C811017 1945  7960   439  16.0  410               5.1
ST.C811017 2000  6500   314  15.0  340               3.8
ST.C811017 2015  7000   400  23.0  505               5.8
ST.C811017 2030  6320   367  20.0  550               6.1
ST.C811017 2130  4210   314  11.0  250               3.6
ST.C811019 1130    43     7                                                            11
ST.C811020 0955    30     4  1.2   18    0.41  3.0  0.29   0.20   5.9   790         2  11  7.5  8.4  642
ST.C811021 1020    33     5                                                            10                 21.
ST.C811022 1020    32     5
ST.C811026 1100     7     2                                                            11                 4.6
ST.C811027 0950     9     4                                                            11                 5.4
ST.C811028 1135    10     4                                                            10                 6.0
ST.C811029 1020                                                                        10  7.7  9.0  676  7.9
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                                                                                  11                    23.
ST.C811007 1030    38    5                                                        11                    10.
ST.C811008 1000    23    2    0.9    18   0.10  2.0   0.23  0.15   7.3   0.81  3  11   7.6   7.6 603    5.5
ST.C811009 1000    18    3                                                        13                    5.0
ST.C811014 1100   940  124                                                        13                    82.
ST.C811015 0935   136   22    2.0    43   0.10  1.4   0.70  0.47   1.0          7  13   7.7   6.5 513    38.
ST.C811016 1110    34    5                                                        11
ST.C811017 1945  7960  438   16.0   410                5.1
ST.C811017 2000  6500  314   15.0   340                3.8
ST.C811017 2015  7000  400   23.0   505                5.8
ST.C811017 2030  6320  367   20.0   550                6.1
ST.C811017 2130  4210  314   11.0   250                3.6
ST.C811019 1100    43    7                                                        11
ST.C811020 0955    30    4    1.2    18   0.41  3.0   0.29  0.20   5.9    790  2  11   7.5   8.4 642
ST.C811021 1020    33    5                                                        10                    21.
ST.C811022 1020    32    5
ST.C811026 1100     7    2                                                        11                    4.6
ST.C811027 0950     9    4                                                        11                    5.4
ST.C811028 1145    10    4                                                        10                    6.0
ST.C811029 1020                                                                   10   7.7   9.0 676    7.9
ST.C811029 1020     8    4    0.6    14   0.14  2.9   0.16   ...   4.0    330  2
ST.C811030 1100    10    2                                                        12                    5.0
ST.C811102 1050    21    2                                                        11                    7.5
ST.C811103 0850   580   70                                                        12                   260.
ST.C811104 1110    49    7                                                        12                    29.
ST.C811105 0935    18    3    0.9    16   0.24  3.1   0.24  0.18   4.8    760  2  12   7.6   8.4 675    15.
ST.C811106 0950    17    4                                                        10                    11.
ST.C811109 1100    13    2                                                         9                    10.
ST.C811110 1020    55   46                                                         6                    8.4
ST.C811111 1330    11    3                                                         6                    8.1
ST.C811112 1000     9    4    0.4    11    0.1  3.0   0.11  0.06   2.7    450  2   6   7.7  11.0 681    8.0
ST.C811113 1440     8    2                                                         6                    6.5
ST.C811116 1440    25    4                                                         6                    16.
ST.C811117 0945    14    4                                                         6                    12.
ST.C811118 0850    10    4                                                         5                    10.
ST.C811123 0900     7    4                                                         6                    5.7
ST.C811124 1100     6    3                                                         5                    5.5
ST.C811125 1040     7    2                                                         5                    6.1
ST.C811130 0955    31    4                                                         5                    29.
ST.C811201 1020   200   32                                                         5                   225.
ST.C811202 1020     7    3                                                         4
ST.C811203 1055                                                                    5   7.9  11.1 655
ST.C811203 1055     9    2    1.7    18   0.43  3.1   0.18   ...   3.2    400  3
ST.C811204 1030    13    5                                                         5                    8.5
ST.C811207 1000     6    2                                                         5                    6.4
ST.C811208 1410     8    3                                                         4                    8.5
ST.C811209 1430     7    2                                                         4                    8.6
ST.C811210 1040                                                                    4   7.9  11.0 660    9.0
ST.C811210 1040     6    0            6      0  3.0   0.08   ...   2.2    390  1
ST.C820130 0830   194    4    ...                      ...
ST.C820130 0945   320   20    ...                      ...
ST.C820130 1245   324   14    ...                      ...
ST.C820216 1430  2510  110    ...                      ...
ST.C820216 1545  1400   50    ...                      ...
ST.C820216 1645  1050   35    ...                      ...
ST.C820217 0930   460   45    ...                      ...
ST.C820217 1420   450   15    ...                      ...
ST.C820219 1400  3950  140    ...                      ...
ST.C820219 1515  3690  135    ...                      ...
ST.C820219 1730  2400   90    ...                      ...
ST.C820222 1020    75    2    ...                      ...
ST.C820315 1635    78   10
ST.C820316 1020   628   64
ST.C820317 1030    54    8
ST.C820318 1035    29    5    1.6    27    .62  4.2    .17   .12   2.8   1000  2
ST.C820319 1030   475   56
ST.C820322 1055    30    0
ST.C820323 1550    20    4
ST.C820324 1015   174   10
ST.C820325 1050   142   20    2.4    39    .97  2.8    .71   .29   4.4   3900  6
ST.C820329 1145    30   10
ST.C820330 0925    19    6
ST.C820331 0925    10    0
ST.C820402 1035    27    5
ST.C820405 1100    70    0
ST.C820406 1015    11    0
ST.D810615 1920  1560   70    3.9    67                1.2
ST.D810615 2000  3520  340    6.9   140                2.7
ST.D810615 2130  2900  340    7.2   163                2.7
ST.D810621 2220  4360  260    7.8   175                      3.2
ST.D810621 2255  3420  300    8.1   170                      3.1
ST.D810621 2340  1960  150    6.6   135                      2.5
ST.D810624 0655  2760  193    6.0   120                2.7
ST.D810624 0730  6950  550    7.6   160                3.2
ST.D810624 2345  8010  431   11.0   230                4.1
ST.D810625 2410  2510  189    6.5   159                2.9
ST.D810704 [illegible]
ST.D810723 0945   673   63
ST.D810723 1100   384   48
ST.D811005 0655  1033   87  5.4  100           1.8
ST.D811005 0755  1430   96  7.1  155           2.2
ST.E810411 0615  4160  210 11.0  205           2.2
ST.E810413 1830  7010  349  9.6  205           2.1
ST.E810413 1845  1270  100  5.4  138           1.7
ST.E810413 1900  6987  329  5.8  134           1.7
ST.E810413 191520500   620 11.0  257           2.5
ST.E810413 193018000   620 12.0  281           2.8
ST.E810413 194520000  1640 11.0  255           2.5
ST.E810413 200018000   790  7.4  176           2.1
ST.E810413 2130  3260  230  3.3   72           1.2
ST.E810411 0630  2370  140  7.4  142           1.7
ST.E810411 0645  7090  365  6.8  111           1.5
ST.E810411 0700  1530  140  5.5   88           1.3
ST.E810411 0715  1520  120  4.8   80           1.2
ST.E810411 0730  2010  150  4.4   69           1.2
ST.E810518 0700  1087  120 12.0  111           2.6
ST.E810518 0715   648   44  2.6   41           0.76
ST.E810518 0730   316   32  2.0   43           0.70
ST.E810518 0745   160    8  1.5   35           0.58
ST.E810518 0800   103   13  1.6   37           0.59
ST.E810518 0815    76   12  2.1   36           0.57
ST.E810518 0830    87   27  3.4   36           0.63
ST.E810518 0845   137   20  3.2   43           0.66
ST.E810624 2245   580   33  3.8   79           1.90
ST.E810624 2255   182   18  1.9   58           1.50
ST.E810624 2305   104   14  1.7   58           1.40
ST.E810624 2315    82   14  1.8   58           1.30
ST.E810624 2325    82   20  2.0   61           1.20
ST.E810704 1700    43    5
ST.F810704 1700    34    5
ST.E810704 1700    26    5
ST.E810704 1700    33    3
ST.E810704 1700    35    5
ST.E810704 1700     6    5
ST.E811005 0500    50   16  3.2   77           2.8
ST.E811005 0515    42   12  3.2   75           2.7
ST.E811005 0630    41   15  3.3   84           3.2
ST.F811005 0500   492   36
ST.F811005 0500   560   44  4.2  110           1.5
ST.F811005 0515   452   32
ST.F811005 0530   377   30  3.3   70           1.6
ST.F811005 0530   283   27  2.6   58           1.2
ST.F811005 0545   263   20
ST.F811005 0600   243   23
ST.F811005 0615   253   27
ST.F811005 0630   280   23
ST.F811005 0645   303   27
ST.F811005 0700   283   27  2.6   58           1.2
ST.F820219 1545   170   17  ...              ...
ST.F820219 1715   190   11  ...              ...
ST.F820219 1730   118   10  ...              ...
ST.F820219 1745   140   14  ...              ...
ST.F820219 1800    80    8  ...              ...
ST.G810615 190025500  1060311.0  760           7.80
ST.G810615 194514100   980 17.0  395           4.40
ST.G810615 2030  9580  680 21.0  450           5.30
ST.G810621 220010280   640 36.0  850           7.90
ST.G810621 2245  9043  629 16.0  385           4.30
ST.G810624 233010490   700 26.0  640           5.30
ST.G810704 1235  3650  193  6.4  163           2.00
ST.G810704 1745  9680  533 15.0  360           3.50
ST.G810704 1810  6490  345  8.4  205           2.40
ST.G810704 1840  5910  337  7.7  175           2.00
ST.H810615 190519100   780 26.0  610           7.20
ST.H810615 [illegible]
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